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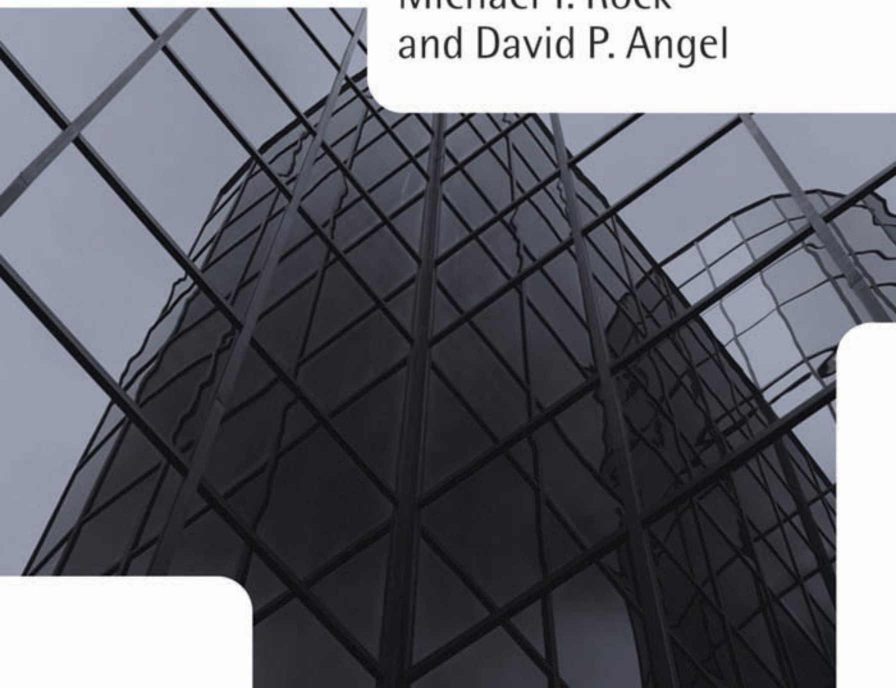
Industrial Transformation in the Developing World

Michael T. Rock
and David P. Angel



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INDUSTRIAL TRANSFORMATION IN THE DEVELOPING WORLD

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For Maggie and Jocelyne

Editors' Preface

Geography and environmental studies are two closely related and burgeoning fields of academic enquiry. Both have grown rapidly over the past few decades. At once catholic in its approach and yet strongly committed to a comprehensive understanding of the world, geography has focused upon the interaction between global and local phenomena. Environmental studies, on the other hand, have shared with the discipline of geography an engagement with different disciplines, addressing wide-ranging and significant environmental issues in the scientific community and the policy community. From the analysis of climate change and physical environmental processes to the cultural dislocations of postmodernism in human geography, these two fields of enquiry have been at the forefront of attempts to comprehend transformations taking place in the world, manifesting themselves as a variety of separate but interrelated spatial scales.

The *Oxford Geographical and Environmental Studies* series aims to reflect this diversity and engagement. Our goal is to publish the best original research in the two related fields, and, in doing so, to demonstrate the significance of geographical and environmental perspectives for understanding the contemporary world. As a consequence, our scope is deliberately international and ranges widely in terms of topics, approaches, and methodologies. Authors are welcome from all corners of the globe. We hope the series will help to redefine the frontiers of knowledge and build bridges within the fields of geography and environmental studies. We hope also that it will cement links with issues and approaches that have originated outside the strict confines of these disciplines. In doing so, our publications contribute to the frontiers of research and knowledge while representing the fruits of particular and diverse scholarly traditions.

Gordon L. Clark
Andrew Goudie
Ceri Peach

Preface

Issues of resources and the environment have manifestly always been 'of the economy'. And yet few would dispute that the environment is now visibly part of the contested dynamics of industrial change in a way not seen in the recent past. The most evident shift is simply an increased awareness of, and concern for, resources and the environment, and an attendant tendency for firms, regions, and national economies to come under greater pressure to address environmental concerns. And yet what perhaps is most notable about the past two decades is not so much the elevated concern for the environment as the opening up for scrutiny and analysis of basic processes of economic and industrial change. During the 1960s and 1970s, environmental protection was constituted largely as an external mandate to firms and industries, leaving the dynamics of investment, production, and technology change outside of the regulatory regime as a reactive black box of economic change. What is now under way is a more direct engagement with economic processes, both by firms themselves, and by policy makers concerned with the relationship between economic growth and the environment. Such processes as technology development, innovation and learning, subcontracting relations, foreign direct investment, and trade are being examined in relation to, and through the lens of, pollution and resource use. The insights gained about these economic processes provide the foundation for this book.

Nowhere is this shift toward a more direct engagement with the economy–environment interface of greater significance than in the industrializing economies of the developing world. Within many developing economies during the 1970s and 1980s environmental mandates simply went unfulfilled as priority was given to growth and economic development. In the absence of a substantive understanding of how processes of innovation, technology transfer, and investment might be harnessed to different development and environmental ends, environmental protection was typically positioned politically as in opposition to the search for poverty-reducing, industry-led economic growth. It is this policy dilemma that provides the starting point for our book. We examine in theoretical and empirical terms the institutional, governance, and policy structures that might support a turn in the trajectory of industrialization to patterns of development that are both

poverty-reducing and less energy, resource, and pollution intensive. In tackling these questions, we necessarily confront the significant changes that are under way within the global economy, from trade and investment liberalization to the emergence of new forms of domestic and international governance of economic change.

Our analysis begins with basic processes of investment, production, and trade—with flows of capital and technology, and with processes of learning and innovation within firms and industrial economies. Only on the basis of an understanding of these economic processes, we argue, can the questions of reducing energy, resource, and pollution intensities be addressed. We make this argument on both conceptual and political grounds. In theoretical and empirical terms, we need to understand the structure and dynamics of industrial change within the contemporary global economy as a basis for identifying institutional forms and points of policy intervention that are likely to be effective in shaping environmental performance. In political and pragmatic terms, any institutional and policy analysis that is not premised upon a prior commitment to understanding how to achieve durable, poverty-reducing industrial growth is unlikely to succeed. We pursue the research as a political economy of industrial change and the environment. That is to say, our interest is in the institutional and relational structures, governance approaches, and policy tools that might support industrial capability building and reductions in the environmental intensity of economic activity in developing economies.

As it turns out, the first part of this analysis—that of understanding the dynamics of technological upgrading and industrial growth within developing economies—is far from simple. Much research—including some of our own prior work—has focused on the experience of the East Asian newly industrializing economies (NIEs) in achieving rapid industrial growth. Less is known about the transferability of the policy approaches used by the East Asian NIEs to other developing economies, or of the implications of new rounds of trade and investment liberalization for the efficacy of these policy approaches. Analysis is complicated by the dynamics of contemporary processes of global economic change, which appear to be changing the locus of points of effective policy intervention on a local, national, and global scale for both development policy and environmental policy alike. Thus the first contribution of this book lies in providing an up-to-date assessment of what we know about the prospects for, and approaches to, achieving technologically dynamic, industry-led growth within developing economies. In particular, we work through the consequences of the most recent phase of economic globalization for technology-upgrading and industry-led growth in developing economies. The second contribution of the book lies in leveraging this understanding into an analysis of how economic processes might be harnessed toward reducing the energy, resource, and pollution intensity of industrialization within developing economies.

The book is based on detailed empirical case studies and statistical analysis of the environmental performance of firms and industries across a range of countries in East Asia. Early on in our work we were struck by the extent of policy and institutional innovation under way within the region, on the part both of firms and of government agencies. Driven by a need to move beyond crude trade-offs between growth and the environment, firms and government agencies were seeking new ways to secure improvements in the environmental performance of industry that took advantage of technological and industrial capabilities building. In effect, these economies were leveraging what had been learnt over the past two decades about how to engage in rapid technological learning and capability building, and deploying this knowledge in a series of policy experiments designed to reduce the environmental impact of industrial growth locally and within the region. One of the key features of this policy and institutional innovation is the greater integration of policies related to environment, trade, investment, and technology development (something we label policy integration), including the adoption of environmental mandates by mainstream agencies of economic development within the region.

Our work is the result of extended collaboration between an economist (Michael Rock) and an economic geographer (David Angel), and by research projects that flow back and forth between applied policy analysis and basic research. We have benefited in this regard from a growing ease of interdisciplinary analysis and from prior efforts at promoting dialogue between geographical economists and economic geographers. We hope the results of this work are of interest to these academic communities and to the many policy makers and practitioners with whom we have had the privilege to work over the past few years. The research presented here does not resolve the challenges of industrial transformation and the environment in the developing world. But we hope to have defined at least one axis of the ways in which reductions in environmental intensities might be achieved within a framework of poverty-reducing growth in East Asia.

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We wish to thank the many individuals and organizations who provided support and encouragement for the research on which this book is based. Early framing of our ideas occurred under the auspices of a series of projects supported by the United States Asia Environmental Partnership and the Asian Development Bank. We wish to thank in particular Owen Cylke, Warren Evans, and Bindu Lohani. Research on the cement industry in East Asia was funded by U S National Science Foundation grant number BCS-0136830. We are grateful to Somporn Kamolsiripichaiporn, Zhang Chonghua, Tubagus Feridhanusetyawan, Kian Foh, Lim Pao Li, and Chang Yii Tan for their research collaboration on this project. Continuing work in this area has been funded by the New Energy and Industrial Technology Development Organization (NEDO) in Japan. Research on policy integration in China and Taiwan was supported by grant number 02-76076-000 from the John D. and Catherine T. MacArthur Foundation. Our work in China would not have been possible without the interest shown by Ms Yu Fei and her colleagues at the State Environmental Protection Administration in China. We thank the many firms in Asia who generously worked with us, including Siam City Cement Ltd. in Thailand and Motorola Inc. in Malaysia. Towards the end of the project we were fortunate to begin to work with the staff of UNIDO in Vienna. We wish to express our appreciation to Joergen Estrup, Frank van Rompaey, Skip Luken, and other UNIDO staff associated with the COMPID project. We are both grateful to our friends and colleagues at Clark University, Hood College, Bryn Mawr College, Winrock International, and elsewhere. The generosity and vision of Harvey Wexler and Joan Laskoff helped make much of this happen.

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List of Abbreviations

AFRM	Alternative Fuels and Raw Material Program
BF	bag filters
BOD	biological oxygen demand
BOI	Board of Investment (Thailand)
CEO	chief executive officer
CEPAC	Central Environmental Policy Advisory Committee
CERES	Coalition for Socially Responsible Economies
CFO	chief financial officer
CIP	Competitive Industrial Performance Index
CO	carbon monoxide
CO_2	carbon dioxide
CPO	crude palm oil
E&E	electronics and electrical (products)
EDB	Economic Development Board (Singapore)
EDMT	Environmental Data Management Team
EHS	environmental health and safety
EMAL	Environmental Materials Assessment Lab
EMC	Environmental Management Corporation (Korea)
EMS	environmental management system
ENV	Ministry of the Environment (Singapore)
EPA	Environmental Protection Administration (Taiwan)
EPB	environmental protection bureau (China)
EPC	environmental protection commission (China)
EPP	environmentally preferred products
EPZ	export processing zone
ESP	electrostatic precipitator
FDI	foreign direct investment
FELDA	Federal Land Development Authority
FLS	F. L. Smidth
FY	financial year
GATT	General Agreement on Tariffs and Trade
GDA	Green Design Advisor
GDP	gross domestic product
GMP	Green Malaysia Program

GPN	global production network
GRI	Global Reporting Initiative
GSP	global supplier program
HC	hydrocarbons
IDB	Industrial Development Bureau (Taiwan)
IFCT	Industrial Finance Corporation of Thailand
ILP	industrial linkage program
ISO	International Organization for Standardization
ITRI	Industrial Technology Research Institute (Taiwan)
JTC	Jurong Town Corporation
KEI	Korea Environmental Institute
KW	kilowatt
LMW	licensed manufacturing warehouse
MNC	multinational corporation
MOCIE	Ministry of Commerce, Industry, and Energy (Korea)
MOE	Ministry of the Environment (Korea)
MSDSE	Ministry of State for Development Supervision and the Environment (Indonesia)
NAFTA	North American Free Trade Agreement
NAPA	National Academy of Public Administration
NGO	non-governmental organization
NIE	newly industrializing economy/new institutional economics
NIER	National Institute for Environmental Research
NIEs	newly industrializing economies
NO_x	nitrous oxide
OECD	Organization for Economic Cooperation and Development
OEE	overall equipment efficiency
OEM	original equipment manufacture
OLS	ordinary least squares
PET	Product Environmental Template
PIMS	Parts Information Management System
PORIM	Palm Oil Research Institute of Malaysia
PPP	purchasing power parity
PRPC	plastics/resins/petrochemical sector
PWB	printed wiring board
R&D	research and development
REAL	Real Environmental Assessment Lab
RFP	requests for proposals
RMB	renminbi
RoHS	Reduction of Hazardous Substances Directive
S&T	science and technology
SCCC	Siam City Cement Public Company Ltd.
SEPA	State Environmental Protection Administration (China)
SMEs	small and medium sized enterprises

SO_2	sulphur dioxide
TCE	transactions costs economics
TFT	tit-for-tat
TLO	Technical Learning Organization Guide Book
TNA	technology needs assessment
TPD	total performance development
TSLS	two-stage least squares
TSP	total suspended particulate
TSR	thermal substitution rate
UEQES	Urban Environmental Quantitative Examination System (China)
UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Program
UNEP	United Nations Environmental Program
UNESCAP	United Nations Economic and Social Commission for Asia
UNIDO	United Nations Industrial Development Organization
US EPA	United States Environmental Protection Agency
VDP	vendor development program
WEEE	Waste in Electrical and Electronic Equipment Initiative
WRI	World Resources Institute
WS	Weberian Scale
WTO	World Trade Organization

1

East Asia's Sustainability Challenge

1.1 Introduction

Since the 1960s, developing Asia has been going through a historically unprecedented process of urbanization and industrialization. This process, which began in East Asia with Japan after World War II (Johnson 1982), then spread first to Korea (Amsden 1989; Rock 1992; Westphal 1978), Taiwan Province of China (Wade 1990), Hong Kong, China (Haggard 1990), and Singapore (Huff 1999) and subsequently to Indonesia (Hill 1996), Malaysia (Jomo 2001), Thailand (Pongpaichit 1980; Rock 1994), and China has spawned enormous interest. While most of the debate surrounding the East Asian development experience has centered on the proximate causes of its development trajectory[1] and the economic[2] and political[3] consequences of this trajectory for the East Asian newly industrializing economies (NIEs), because Asia looms so large in the global economy and ecology, interest has belatedly turned to the environmental consequences of East Asia's development path and to the political economy of governmental responses to deteriorating environmental conditions in the region (Brandon and Ramankutty 1993; Rock 2002*a*).

The focus on the environment came none too soon. Rapid urbanization,[4] industrialization,[5] and globalization in the East Asian NIEs, when combined with 'grow first, clean up later' environmental policies, have resulted in

[1] This debate largely revolves around the efficacy of industrial policy. For an introduction to this debate see World Bank (1993) and Wade (1990).

[2] There has been enormous interest in the shared growth consequences of this process (Campos and Root 1996).

[3] There is substantial interest in the democratization that has attended this process.

[4] Rapid urbanization meant that urban populations have increased from 133 million, or 16% of the total population, in 1960, to 615 million, or 38% of the population, in 2002 (World Bank 2004). This 4.6-fold increase in urban populations contributed to the rise of the region's megacities—Shanghai, Beijing, and Seoul in Northeast Asia, and Bangkok, Jakarta (and Manila) in Southeast Asia—which dominate the social, political, environmental, and economic landscapes of these newly industrializing economies.

[5] Between 1971 and 2002, industrial value added grew by an annual average of 8.73% in the East Asian newly industrializing economies compared to 1.59% in the Middle East and North Africa, 5.65% in South Asia, 3.56% in sub-Saharan Africa, and 3.32% in Latin America and the Caribbean (World Bank 2004). Because of this, industrial production rose 17 fold from $65.3 billion (in constant 1995 dollars) in 1971 to $1.13 billion (in constant 1995 dollars) in 2002,

average levels of air particulates approximately five times higher than in OECD countries and twice the world average (Asian Development Bank 1997). Not surprisingly, of the 60 developing country cities on which the World Bank (2004: 164–5) reports urban air quality, 62% (10 of 16) are in developing East Asia, all but one of the rest are in South Asia. Measures of water pollution in East Asia, such as biological oxygen demand (BOD) and levels of suspended solids are also substantially above world averages (Lohani 1998). With the prospect for further rapid urban-industrial growth rooted in the attraction of foreign direct investment and the export of manufactures in East Asia, the rest of Asia, and the rest of the developing world as the East Asian 'model of development'[6] spreads, local, regional, and global environmental conditions may well get worse before they get better (Rock *et al.* 2000).

At the core of this environmental challenge in East Asia is rapid urban-industrial growth. This urban-industrial growth is itself based on a highly successful dynamic of technological upgrading and industrial capability building that has allowed the East Asian NIEs and China to emerge as the industrial hub for the global economy. Manufacturing firms in East Asia have learnt how to develop and deploy product and process technologies and to meet global expectations for quality and on-time delivery, and they have leveraged these successes along with low labor costs to capture a substantial share of global industrial output. East Asian governments have found multiple ways to support this technological upgrading and capability building, and to bridge these processes into a dynamic of poverty-reducing economic growth.

It is this demonstrated capacity for industrial transformation and institutional innovation within East Asia that motivates this book. We seek to understand the conditions under which innovation and technological capacity building within the East Asian NIEs might be harnessed toward the parallel task of driving down the energy, materials, and pollution intensity of economic activity and toward improving environmental quality locally and globally. Does East Asia have within its grasp the capacity for a further round of institutional innovation and industrial transformation, one directed toward balancing concerns for economic growth with those of environmental improvement? Is there any evidence to suggest that industrial firms in developing Asia can reduce energy, materials, and pollution intensities to levels that offset significantly the scale effects of rapid industrial and urban growth within the region? And in the same way that low income economies through-

doubling its share in the GDP of the East Asian NIEs from 21.9% in 1971 to 45.6% in 2002 (World Bank 2004). In the rest of the developing world, industry's share in GDP averaged only 30% in 2002 (World Bank 2004).

[6] We use the term 'model' advisedly both because there is no one East Asian model (see e.g. Booth 1989) and because there is substantial disagreement over major elements of the East Asian model.

out the world looked to East Asia as a model for leveraging integration into the global economy toward poverty-reducing growth, are there lessons to be learned by developing economies from the ways in which the East Asian NIEs are beginning to address issues of environmental performance of industry?

These questions place this book squarely within some of the grand development and environmental debates of the past decade. Under the various labels of globalization, environmental sustainability, and development, a very large literature has emerged seeking to understand the consequences of globalization for social and economic welfare and environmental quality in developing economies, and of the efficacy of different institutional and policy responses to the challenges of economic globalization (see e.g. Bhagwati 2004; Chang 2002; Dua and Esty 1997; Korten 1995; UNDP 2003). Of particular relevance to the current study are debates within the literature of ecological modernization over the capacity of capitalist political economies to truly address current sustainability challenges (for excellent reviews of these literatures see Hajer 1995; Mol and Sonnenfeld 2000). While the research presented here connects to these literatures, we do not in the first instance seek to resolve some of the underlying questions regarding institutions and governance in an era of economic globalization in theoretical terms. Rather we take a pragmatic (but theoretically informed) approach that begins with an exploration of actual cases of policy innovation and industrial environmental performance improvement by firms and industries within East Asia. As one observer (Clark 1998) has put it, we are in this book studying economic globalization 'on the ground' through an examination of the strategies and actions pursued by actual firms and industries in the region.

Based on these studies, we describe an emerging response within East Asia to the challenge of improving the environmental performance of industry—one that links traditional environmental regulatory agencies and policies to open economy policies and to technological upgrading policies—something we label policy integration. We focus on policy integration both because we have uncovered substantial evidence of its effectiveness in the East Asian NIEs (Chapter 3) and because it provides an important opportunity to achieve win–win technology or technique effects (Copeland and Taylor 2003), which offset, at least partially, the negative environmental scale effects of rapid urbanization, industrialization, and globalization. This is important because most developing countries are unwilling to invest heavily in the environment if this comes at too high a cost in terms of growth forgone. Stated another way, in the absence of a substantive understanding of how processes of innovation, technology transfer, and investment might be harnessed to different development and environmental ends, environmental protection will typically continue to be positioned politically as in opposition to the search for poverty-reducing, industry-led economic growth.

Our case studies and empirical work describe remarkable progress on the part of firms and industries in improving environmental performance. We document in detail the emergence of Thai cement plants that are among the most economically competitive and environmentally efficient producers worldwide. We consider the gains in environmental performance that are occurring in China as obsolete locally sourced production technologies are replaced by leading-edge technologies sourced within OECD countries within the context of very rapid economic globalization. We examine the ways in which the supply chains of major North American and European electronics manufacturers are transforming the environmental performance achieved by first and second tier suppliers located in East Asia. We look at the use of global firm-based environmental standards as a way of managing complex sourcing issues across multiple production sites and customer markets. And we detail the extension of some of these principles into the arena of urban environmental quality in terms of urban environmental performance management in China. What we find does not in any way add up to a resolution to the environmental challenges facing the region and the global economy at large. But the scope and scale of success in improving environmental performance of industry does begin to define at least one axis of a potential policy response to the challenge of environmental sustainability in East Asia.

In theoretical terms we enter the problem of industrial growth and the environment through the meso-level analytics of technological upgrading and industrial capability building. Given the importance of technological upgrading to the economic success of firms and industries within the East Asian NIEs, this is in practical terms an important entry point to any analysis of the processes of economic change under way within the region. But further than that, the conceptual architecture that we employ here is based on the claim that the shifting trajectory of environmental performance of firms cannot be understood outside of a prior analysis of the fundamental firm-based processes of investment, technology change, and innovation that are at the core of technology upgrading and capability building. As it happens, these fundamental economic processes are themselves undergoing significant change in response both to economic globalization and attendant policy responses, and to environmental mandates that are impacting industrial firms around the world. The new rules of the World Trade Organization (WTO), for example, appear to limit use by developing countries of many of the industrial capability building programs used successfully by the East Asian NIEs that engaged in high-speed industry-led growth and technological upgrading from the 1960s through to the 1990s (Chang 2002). At the same time, an apparent consolidation of global supply chains in response in part to a need to manage environmental performance more tightly appears to be changing the opportunities available to low income countries who wish to 'climb the ladder' of technological upgrading and industrial capability building.

As we examine technological upgrading from the perspective of environmental performance, we find that the processes under way relate directly to issues of firm-level and network-based learning and innovation and are not compartmentalized within a narrow domain of industrial environmental concerns. Indeed we would go so far as to suggest that studies of the ways in which industrial firms are seeking to meet actual and anticipated environmental mandates are providing new insights into the dynamics of technological upgrading and economic change in general (see also Bridge 2002). Whether it be in terms of the role of firm-based standards as a tool for managing complex global firms operating in multiple differentiated environmental regulatory contexts, or technological learning around environmental issues in supply chains, environmental performance is emerging for many firms as simply one more dimension of industrial competitiveness, along with product quality, inventories, and on-time delivery, to be managed as part of an integrated performance accounting framework.

Because of the emphasis we place here upon technological upgrading and capacity building, parallels will likely be drawn to studies of industrial ecology and industrial metabolism. The latter work, pioneered by Allenby (1999), Ausubel and Sladovich (1996), Ayres and Ayres (1996), and Graedel and Allenby (1995), seeks to examine the ways in which the material basis of production processes might be reconfigured to reduce the ecological footprint of economic activity. In much of this work, the focus is on materials flows and technology *per se*, as for example in life cycle analysis of different technologies in the automobile industry, or pulp and paper. Whereas industrial ecology provides important insights into *how* industrial processes might be reconfigured, the work is less convincing in its analysis of the institutional conditions under which these processes *will* be reconfigured and are being reconfigured within the global economy today. It is here most fundamentally that we hope the book makes a contribution. Building on what has been learnt from industrial ecologies, our book focuses on the economic, social, and institutional conditions under which technologies are used, transferred, modified, and adopted as part of processes of industrial development. Through these studies, we begin to define institutional frameworks and policy tools that support substantial improvements in the environmental performance of industry within the East Asian NIEs. As indicated, we conclude that the leading-edge of institutional innovation revolves around processes of policy integration that seek to build environmental concerns into the mandates of primary institutions of economic development and that integrate policy approaches across different domains, from trade to investment and land use.

Our argument proceeds in a series of discrete steps. In the remainder of this chapter, we outline the dimensions of East Asia's historically unprecedented sustainability challenge and delineate a policy response that links industrial environmental improvement policies to open economy policies

and to technological upgrading policies—something we label policy integration. Since our policy response is predicated on linking industrial environmental improvement policies to technological upgrading policies, we begin by outlining (Chapter 2), in some detail, what we know about technological upgrading policies in the first and second tier East Asian newly industrializing economies and empirically demonstrate that technological upgrading policies contributed to the competitiveness of industry in these economies. From there, we turn in Chapter 3 to demonstrating precisely how governments in four East Asian newly industrializing economies actually practice policy integration by linking industrial environmental improvement policies to open economy policies and technological upgrading policies. We go one step further by explicating and testing a fairly simple model of policy integration based on the determinants of differences in the carbon dioxide intensity of industrial value added in a group of Asian economies over time. To anticipate findings, we empirically demonstrate that an integrated package of policies—industrial and technology policies, resource pricing policies (for energy), stringent environmental regulations, and openness to foreign direct investment—has significantly reduced the carbon dioxide intensity of industrial value added in those East Asian economies that have most forcefully practiced policy integration.

Chapter 4, which draws on an econometric analysis of the determinants of pollution abatement expenditures in a survey sample of manufacturing plants in several sectors in two East Asian NIEs—Korea and Indonesia—provides solid empirical support for one of our primary conclusions in Chapter 3, namely that effective policy integration starts with the building of an effective command and control environmental regulatory agency that has the technical and political capability and the resources necessary to get manufacturing plants to invest in pollution control. This is important to demonstrate because some have doubted whether governments in the East Asian NIEs in particular, or in the rest of the developing economies more generally, have either the interest or capability to develop an agency capable of designing and implementing traditional command and control regulatory policies. The evidence provided in this chapter suggests that these concerns are misplaced.

The next four chapters (Chapters 5 to 8) focus on how governments and firms in the East Asian NIEs have used openness to trade and investment to improve industrial environmental outcomes. We demonstrate (Chapter 5), through an econometric analysis of a survey of manufacturing plants in a particularly dirty industry, cement, in four East Asian NIEs, China, Indonesia, Malaysia, and Thailand where cement manufacture is a large industry, that openness to trade, foreign investment, and foreign technology significantly lowers, by a factor of two, both the energy intensity and the pollution intensity of cement manufacture in these economies. While we admit that these reductions in energy and pollution intensity, or what Copeland

and Taylor (2003) label technique effects, may not be sufficient to achieve sustainable industrial development, these 'win–win' opportunities are nevertheless important because they have enabled these developing economies in East Asia to offset at least some of the negative environmental scale effects of growth. Because we demonstrate (Chapter 2) that firms are unlikely to be able to reap these technology or technique effects unless they invest in a 'hard slog' to successfully build their technological capabilities, we follow with an in-depth case study (Chapter 6) of firm-level investments in capabilities building in one large cement company in one East Asian NIE, Thailand. We show how this Thai firm's long-run investments in technological capabilities building enabled it to capture these technique effects so successfully that by the time it became a joint venture partner with a prominent European multinational cement conglomerate it was already the best performing plant in the conglomerate. Because of this, engineers at this plant are being tapped by the European cement conglomerate that 'owns' them to provide technical advice to the conglomerate's other plants all over the world.

We extend our study of the technology or technique effect (Chapter 7) to the relationships between a large multinational (in electronics) and its small and medium sized suppliers in the developing world, in this instance in Penang, Malaysia. This case study shows, in some detail, how even smaller firms in the East Asian newly industrializing economies can take advantage of their participation in the global value chains of multinational corporations to improve their industrial environmental performance. This finding is important for two reasons. It suggests that governments just might be able to reach the large number of small and medium sized firms that usually lie beyond the grasp of government regulatory agencies by adding environmental dimensions to their vendor development programs or industrial linkage programs that link multinational corporations to the small and medium sized firms that supply them. Because linking small and medium sized firms to the global value chains of multinational corporations has been proven to be an important avenue for technological capabilities building in several East Asian NIEs (Chapter 2) and because it is less demanding of governments than alternative approaches to technological capabilities building (Chapter 2), this avenue to industrial environmental improvement is likely to be particularly attractive to governments in the rest of the developing world, particularly the lower income economies (Chapter 10). We make one final point about the relationship between globalization and sustainability by arguing (Chapter 8) that an emerging system of global, private, multinational firm-based environmental standards, when combined with public pressure for better environmental outcomes, may well be both an alternative to the creation of a supra-national environmental regulatory agency that some have called for or for more international environmental treaties and an attractive way for governments and firms in the low income economies to tap into intensity-reducing technique effects.

Having demonstrated how and why policy integration works, we finally ask (Chapter 10) what the rest of the developing world, particularly the low income economies, can learn from the various and varied experiences with policy integration in the East Asian NIEs. This question is important because some will, no doubt, view the integration of policies across three normally independent policy domains and numerous government agencies as difficult if not impossible to achieve, particularly in low income economies where governments tend to lack much bureaucratic capability. We answer this question in two discrete steps. To begin with, we empirically demonstrate that most of the low income economies fail to meet even the most basic enabling conditions (Chapter 2) for successful policy integration. In these economies, it is important for governments to turn their attention first to providing political stability, macroeconomic stability, good governance, an increasingly skilled labor force, and ample physical infrastructure. Once this is accomplished, we show how governments in the rest, particularly the low income economies, can turn their attention to policy integration—the linking of technology policies and open economy policies to industrial environmental improvement policies. Because of the general weaknesses of governments in the lower income economies, we argue that this can best be done by vendor development programs or industrial linkage programs that link small and medium sized firms to the global value chains of multinational corporations. We demonstrate this by a case study for one low income economy in sub-Saharan Africa—Ghana—and we extend the analysis to other low income economies by drawing on the results of a survey in roughly 25 low income economies. Our central message here is that most of the rest, particularly the low income economies in the developing world, should be able to reap win–win technology, technique, or intensity effects by linking their small and medium sized firms to the global value chains of multinational corporations. But before making the case for policy integration, we outline both the sustainability challenge associated with East Asia's rapid urbanization-industrialization-globalization and a policy response.

1.2 The Sustainability Challenge

As noted above, rapid urban-based industrial growth, particularly of manufactures, has been at the core of the model of development pursued by the East Asian NIEs over the past 40 years.[7] Because industrialization largely took place in urban areas, cities came to account for a disproportionate share of GDP, industrial output, and pollution. Two examples should suffice. Until

[7] This is not to denigrate the importance of intensification in smallholder agriculture, or of massive investments in basic education, basic health care, family planning, and in infrastructure, particularly rural infrastructure, to the success of the East Asian shared growth model.

recently, the Bangkok metropolitan region of Thailand accounted for almost one-half of Thailand's GDP and a little more than 75% of manufacturing value added (World Bank 1994*a*: 8). Four cities on Java (Jakarta, Surabaya, Bandung, and Semarang) account for 36% of Java's and 27% of Indonesia's industrial output (World Bank 1994*b*: 75) while the urban share of industrial production on Java is expected to rise from 55% to 70% by 2010 (World Bank 1994*b*: 75). Not surprisingly, the coincidence of industrialization with urbanization means that cities generate most of the East Asian NIE's industrial pollution load (70% in Indonesia) (World Bank 1994*b*: 80). When combined with rapidly growing emissions from household fuel use, rising emissions from vehicular traffic, and 'grow now, clean up later' environmental strategies (Rock 2002*a*), the result is average levels of air particulates approximately five times higher than in OECD countries and twice the world average (Asian Development Bank 1997).

These urban-industrial environmental problems also reflect an initial reliance on materials, energy, and water-intensive technologies in pollution-intensive manufacturing and resource-processing industries. One consequence of this is a high energy intensity of GDP such that it currently takes 54% more energy to produce a dollar of GDP in the East Asian NIEs than it does in Japan (World Bank 2004). Certain other types of pollution have also been growing faster than GDP. The toxic intensity of GDP in Indonesia increased 5.4 times between 1976 and 1984. Comparable figures for Malaysia (3.05 times), Thailand (2.48 times), and Korea (2.5 times) are equally worrying (Brandon and Ramankutty 1993: 74). Because this toxic intensity is largely related to the composition of output, particularly the share of petrochemicals and electronics in industrial production, and weak regulatory systems, particularly in the lower income economies, there is no reason to believe that these intensities have been falling.

Given this urban-environmental present, what can we say about the East Asian NIE's environmental future? Projections of urban-environmental outcomes are sensitive to five distinct sets of assumptions. First, outcomes depend on expected increases in urban populations and whether those populations are concentrated in ever-larger mega-cities or spread across a wider range of smaller cities. Second, outcomes depend on how well urban governments manage the environmental consequences of expected increases in population, affluence, and economic activity. This includes the ability to influence locational patterns through urban planning and zoning. It also includes the ability to manage future expansions in urban infrastructure, to improve the quality of services provided by investments in infrastructure, to recover the costs of those investments, and to involve citizens and communities in decision-making. Third, outcomes depend on the scale of projected increases in economic output and on the spatial concentration of that output. Fourth, they will depend on the composition of expected increases in output, particularly the share and composition of manufactures in increased output, on the efficiency of water,

materials, and energy use in manufactures, and on the pollution intensities of manufactures. Finally, outcomes will depend on the policy responses of governments to expected increases in pollution.

While no one has yet developed a comprehensive model to project urban-environmental outcomes based on assumptions in each of these areas, the broad outlines of most likely possibilities are now visible. To begin with, the World Resources Institute (1997: 151) projects that the urban population in the East Asian NIEs will increase from about 572 million in 2000 to approximately 1.1 billion in 2025, increasing the share of the population living in cities from 36% in 2000 (World Bank 2004) to 57% in 2025 (World Resources Institute 1997: 151). This means that the increase in urban population (by roughly 533 million) will exceed the total expected increase in population (roughly 360 million) in these countries by about 48% (World Bank 2004 and World Resources Institute 1997: 151). This will result in nearly a 95% increase in the number of people living in urban areas and it will represent the largest increase in the absolute size of urban populations in these countries in their entire histories. It will also mean that for the first time in the East Asian NIEs' history most of the population (roughly 57%) will live and work in urban areas.

This absolute increase in urban population is likely to challenge the capacity of urban governments to manage growth effectively. Unless urban planning and zoning improve, cities are likely to continue to grow by spreading and sprawling into the urban fringe. Unless urban governments increase their capacity to tax and finance urban infrastructure and manage it more efficiently, meeting the infrastructure needs of this kind of population growth will not be easy. Yet, if governments fail to plan and zone better and significantly expand and improve the efficiency of infrastructure services for safe drinking water, treatment of human wastes, collection and disposal of garbage, or for transporting people and goods, urban-environmental quality will only get worse, perhaps much worse. There is at least one vivid example of how this may happen. As we now know, air pollution from mobile sources—from cars, trucks, buses, and motor bikes and motor cycles—in the East Asian NIEs accounts for a rising share of total air pollution. If present practices, which contribute to urban sprawl, lack of mass transit alternatives, and limited regulation of mobile sources of air pollution, continue, congestion will grow and urban air quality will continue to decline.

Future population growth in the East Asian NIEs' cities will also largely be determined by the expected economic growth in those cities. To take but one example, in China industrial GDP is expected to increase by nearly 7% per year through 2020 (World Bank 1997: 30). This means that industrial output will expand from roughly $545 billion (in constant 1995 dollars) in 2000 to roughly $1.85 trillion (in constant 1995 dollars by 2020 (World Bank 2004)). Similar developments are observed elsewhere in the other lower income East Asian NIEs. For example, between 1961 and 2002 industrial output in

Indonesia increased by almost 19 times in real terms, increasing its share from about 15% of GDP to 45% (World Bank 2004). Yet, some (pre-crisis) estimates suggest that Indonesia's urban-based industrial sector could increase another 13 times by 2020 (World Bank 1994*b*: 74). As in China, this represents the largest increase in industrial production in Indonesia's history. Similar developments are expected in Thailand.[8]

What this means for industrial pollution loads (and ambient environmental quality) depends on the rate of growth of industrial output; the changing sectoral composition of industrial output; the energy, materials, water, and pollution intensity of that output; and the spatial spread or concentration of industrial activity. The net effect of these factors is a projected reduction in some measures of the pollution intensity of industrial activity but not enough to reduce large overall increases in pollution loads. For example, the World Bank in 1994 projected modest declines in the pollution intensity of industrial activity in Indonesia for particulates, BOD, and toxics (but not bio-accumulative metals) between 1995 and 2020 as a result of shifts into industrial sectors that were less polluting. Despite this, the World Bank predicted that these declines would be overwhelmed by a 13-fold increase in industrial production. As a result, they projected a 10-fold increase in water pollutants, a 15-fold increase in emissions of suspended particulates, and a 19-fold increase in emissions of bio-accumulative metals, such as mercury and lead.

A second World Bank study demonstrates how changes in the assumptions made concerning pollution intensity result in quite different outcomes (World Bank 1997). The 'business as usual' scenario in this second study predicted a more rapid decline in pollution intensity within industrial sectors, based upon the assumption that all new capital investment would have emissions that were 25–50% lower than the existing capital stock. Pollution intensity would fall as new, cleaner technology increased as a share of the total capital stock. Under this more favorable scenario, particulate levels (a measure of air quality) in Jakarta were predicted to increase by only about 60% over the period 1995–2020. This represents an improved outcome over that projected in the 1994 World Bank study, though it still is expected to contribute to a marked decline in air quality. It is only under scenarios that assume much more rapid declines in pollution intensity that urban air quality is projected to improve in lower income East Asian developing market economies.[9]

Beyond pollution *per se*, virtually all researchers predict large-scale increases in energy use and attendant greenhouse gas emissions in developing Asia over coming decades. For example, Carmichael and Rowland (1998)

[8] For discussion of what is expected to happen in Thailand and Singapore through to 2025 see Rock (2000).

[9] In this 1997 World Bank study, the business as usual scenario for water pollution assumes very rapid declines in pollution intensity of BOD emissions from large industrial sources (largely via end-of-pipe pollution control).

project that current pollution prevention programs, if widely implemented in Asia, have the potential to yield a 30% improvement in energy efficiency of economic activity by the year 2020. But even if such efficiency improvements are achieved, energy usage is still expected to double by 2020. The US Department of Energy (2004) expects a similar doubling of energy use in developingAsia over this same time period. Because of this, greenhouse gas emissions will also likely double and developing Asia will likely overtake the OECD economies as the largest source of greenhouse gas emissions worldwide.

As the events of the late 1990s in the East Asian NIEs have shown, projections of economic and environmental futures carry within them considerable uncertainty. Nevertheless, absent new policy interventions, environmental conditions are unlikely to improve substantially in the lower income economies of East Asia, and there is a strong possibility that at least some dimensions of environmental quality will deteriorate. In the remainder of this chapter, we consider what forms of policy intervention are likely to yield substantial improvements in the energy, materials, and pollution intensity of industry in developing East Asia.

1.3 The Development Context

The pursuit of more sustainable urban-industrial outcomes in the East Asian NIEs depends heavily on the development context. Three elements of the development context are of particular importance. First, most of the low income countries in East Asia, including the second tier East Asian newly industrializing countries (Indonesia, Malaysia, Thailand, and China) and the rest (the Philippines, Vietnam, Papua New Guinea, Laos, Cambodia, and Myanmar), are still in the early stages of their industrial revolutions. Because of this, most of the industrial stock that will be in place 25 years from now is not on the ground today. In China, for example, fully 80% (World Bank 1997: 57) of the industrial stock of plant and equipment that will be in place in 2020 has not yet been built. The comparable figure for Thailand is 89% (Rock 2000) and for Indonesia is 85% (World Bank 1994*b*:166). What this means in practice is that East Asia will likely see the most prodigious expansion of industrial activity in their own histories and in the history of the world. This is both a threat to sustainability and an opportunity to shape, at an early stage, the energy, materials, and pollution intensity of this trajectory of urban-industrial development. If actions are taken now, there is a once in a lifetime opportunity to achieve a lower and more sustainable growth trajectory. This opportunity is significantly different from that faced by the OECD countries when they launched their environmental programs in the 1970s. Then the recognized problem was not primarily how to make the new industrial capital stock cleaner but rather how to retrofit a large existing

capital stock with end-of-pipe controls to reduce emissions after they were produced.

Second, as O'Connor (1994) has noted, the late-comer status of the East Asian developing market economies within the global economy is an important context for policy response. This is particularly the case with respect to technology, where indigenous firms in the developing market economies have access to an array of environmentally advanced technologies developed within the OECD economies. There is now considerable evidence that in many industries newer plant and equipment developed mainly within the OECD economies tends to be cleaner than existing plant and equipment (see Chapters 5, 6, and 7 in this book; Repellin-Hill 1999; Arora and Cason 1995; Christensen *et al.* 1995; Greiner 1984; Wheeler and Martin 1992). One industry specific example makes this clear. As Wheeler and Martin (1992) demonstrate, the 1970 Clean Air Act in the US led pulp and paper making firms to shift production processes from a chemical to a thermo-mechanical process. This new thermo-mechanical process for making pulp proved to be both less polluting and economically superior to the older chemical process. What is most interesting about this technological shift is that Wheeler and Martin (1992) demonstrate that the speed of adoption and diffusion of this cleaner and more productive technology in developing countries is critically dependent on a country's policy toward trade and investment. Those countries with more open trade and investment policies adopted and diffused this newer and cleaner technology faster than those with protectionist trade and investment policies.

This example suggests that it may be technically and economically possible for manufacturers in the East Asian developing market economies, including China, to import, operate, adapt, modify, and innovate on an industrial capital stock that will tend to be cleaner simply because it is newer.[10] The policy challenge is to promote the selection and use of this cleaner process technology in new industrial investment. Because the majority of technology design and development remains centered within OECD countries, technology policy within the OECD will be crucial to achieving clean development in Asia. But, as is argued in Chapter 2, because technology transfer is not automatic, simple, easy, or costless, technology policies and technology support institutions in the developing market economies of East Asia that encourage local firms to import, adopt, adapt, and innovate on cleaner process technologies obtained from OECD firms are equally important. In both regards, the critical technology is not that of end-of-pipe control, but new and improved product and process technologies that are designed to achieve higher efficiencies in energy and materials use.

Third, rapid urban-industrial growth in East Asia has occurred in tandem with rising openness to trade and investment within the world economy.

[10] We do not, however, have good data on the extent to which manufacturers are investing in cleaner technology within Southeast Asia. Because most existing policy presumes a 20–30% improvement in energy and materials efficiency simply through the use of newer, cleaner technology (see, for example, World Bank 1997), this is a critical policy issue.

Trade as a percentage of GDP among the East Asian newly industrializing economies and China increased from 36% in 1970 to 109% in 2002 (World Bank 2004). In 1997, East Asia and China were the destination for approximately half of worldwide foreign direct investment (World Bank 2004). And while good data are not available, it is estimated that as much as 80% of new technology and capital equipment in developing Asia is sourced from OECD economies. Two consequences follow with respect to efforts to reduce the pollution intensity of industrial output in developing East Asia. First, shaping the pollution intensity of these international technology and capital flows will be an important part of a policy approach to clean development. Second, as several chapters in this book demonstrate, the growing interconnectedness of producers and markets in East Asia and the rest of the world is potentially an important point of leverage in promoting improved environmental performance of industry in Asia.

Open economies are already exposing manufacturers in the developing market economies of East Asia to an increasingly wide range of environmental market pressures. Sometimes this takes the form of green consumerism, green labeling, and greening of supply chains (see Chapter 5 for a discussion of this with respect to electrical and electronic goods). Sometimes it takes the form of new international voluntary environmental management standards (ISO 14000) or of industry codes of conduct (Roht-Arriaza 1995). And sometimes it takes the form of corporate disclosure and accountability (as in the rapid growth of corporate environmental reporting) (Ditz and Ranganathan 1997 and UNEP 1999) and multinational firm-based environmental standards (see Chapters 6, 7, and 8). Because the shared growth miracles in East Asia are predicated on the export of manufactures to countries in the OECD, these external pressures will likely increase over time. While we provide some very substantial evidence of the impact of these drivers on the environmental performance of industry in East Asia (Chapters 4, 6, 7, and 8), systematic assessment of the effects of these market and corporate drivers is, however, not yet available and claims regarding efficacy must continue to be treated with caution. Despite this, in our view, the successful developing country exporters of manufactures in East Asia and in the rest will continue to face these pressures, forcing them to learn how to meet environmental market requirements the same way they learned to meet developed country buyers' on-time delivery, quality, and packaging requirements (Keesing 1988). Increasingly open polities reinforce these external market demands for sustainability. As we now know, citizens, communities, and organized groups in civil society in each of the developing market economies of East Asia are placing increased pressure on governments and private sectors to reduce the energy, materials, and pollution intensity of industrial production (Rock 2002*a*; Lee and So 1999). In some places, such as Indonesia and China, public sector environmental agencies are taking advantage of public and community pressure to devise low cost enforcement strategies

that take advantage of the concern of firms for their (environmental) reputations (Afsah and Vincent 2000).

Jointly these three dimensions of the development context suggest that influencing the energy, materials, and pollution intensity of new industrial investment and attendant production practices is both a critical opportunity and a policy imperative within the developing market economies of Asia. What policies are likely to be effective in securing this goal within developing East Asia?

1.4 Policy Integration

Several researchers (see Chapter 5 in this book; World Bank 1997; World Bank 1994*b*; and Wheeler and Martin 1992) have found that newer industrial plant and equipment developed within the OECD tend to be cleaner than existing industrial plant and equipment in East Asia. Given the openness of the East Asian economies to foreign investment, this would suggest that new investment will likely yield improvements in pollution intensity. But there are several reasons to suppose that the process of capital turnover and new investment itself will not yield the substantial reductions in overall pollution intensity required to offset increases in the scale of industrial output in rapidly industrializing Asia. First, there is little doubt that some of the 'new' investment in the second (Indonesia, Malaysia, Thailand, and China) and third (the Philippines, Cambodia, Lao PDR, Papua New Guinea, and Vietnam) tier developing market economies of East Asia consists of older and dirtier capital in sunset industries. Several of the first tier developing market economies (Korea, Taiwan Province of China, and Singapore) have encouraged the export of low technology labor-intensive industries such as textile dyeing, leather-making, and simple electro-plating to China, Indonesia, Malaysia, and the Philippines. Some (Hsiao 1999: 44; Rock 2002*a*) have suggested that this is the natural outcome of shifting comparative advantage. This suggests that openness to foreign investment alone might just as easily promote dirtier industrial outcomes. This tendency can be and has been exacerbated by inappropriate pricing policies for energy, water, and other materials in some of the developing market economies and by corrupt and rent-seeking behavior of government officials and private sector actors.

Second, the selection of cleaner production technologies, the effectiveness of their subsequent use, and the tendency to pursue ongoing process changes that reduce pollution intensities depend crucially on the effectiveness of regulatory policies (see Chapter 4) and non-regulatory drivers (see Chapter 5) of improved environmental performance. But East Asia's experiences with environmental regulatory policies are mixed. Singapore stands at one end of the spectrum. The country's strong anti-corruption laws and practices facilitated the introduction of tough command and control regulation and

enforcement as early as 1970 and it successfully integrated its environmental agency into industrial policy-making (Chapter 3). Despite its tough environmental regulations, Singapore has been uniquely successful among developing countries in building a large industrial base on foreign investment by multinationals. It is also perhaps the only developing country that largely avoided significant environmental deterioration during high-speed industrial growth. Since the late 1970s, ambient air and water quality has rivaled that in the other OECD countries. This suggests what can be done if governments become more committed to cleaner development. Korea and Taiwan Province of China both followed more typical 'grow first, clean up later' environmental strategies (Rock 2002*a*; O'Connor 1994), and the government of Taiwan Province of China, like Singapore, has had some success in integrating its regulatory agency with the institutions of industrial policy (Chapter 3). There is some evidence that those agencies are beginning to make an environmental difference (Chapter 4; Rock 2002*a*). Malaysia (O'Connor 1994; Vincent *et al.* 2000) has also had some limited success at creating a tough command and control environmental agency and integrating it with the institutions of industrial policy (Chapter 3). Others, particularly Thailand, Indonesia, China, and the Philippines, are farther behind (Rock 2002*a*). Their regulatory agencies are much weaker. Others, such as Cambodia, Laos, and Vietnam, have exceedingly weak or virtually non-existent environmental agencies.

The evidence suggests that the developing countries in East Asia with anti-corrupt, competent, tough but fair environmental agencies can get firms, including foreign investors, to install end-of-pipe controls that contribute to better ambient environmental quality (Rock 2002*a*; Chapter 4; Rock 1996*b*; O'Connor 1994). Unfortunately, this approach, by itself, suffers from a multitude of problems. To begin with, it comes at high cost and the investment of too much time (Ooi 1994). Some have suggested that the cost of this approach is increasingly prohibitive, particularly for developing countries (Hazilla and Kopp 1990; Russell 1990; O'Connor 1994). In addition, all too often, these agencies have attempted to do too much too fast. This is particularly true regarding the use of market-based instruments. All the East Asian newly industrializing countries use one or more market-based instruments. For the most part, these have not worked and they have badly stretched the administrative capacity of nascent regulatory agencies (Rock 2002*a*; Panayotou 1999; Spofford *et al.* 1996). Those that have learned how to economize on limited administrative capacity by drawing on innovative public disclosure programs do so by focusing on end-of-pipe solutions to pollution (Afsah and Vincent 2000). This means that, with very few exceptions, none of the regulatory agencies in East Asia effectively promote cleaner production or pollution prevention. To make matters worse, virtually none of these regulatory programs reaches the very large number of small and medium sized factories that have sprouted up over the industrial landscape.

In sum, command and control regulatory policies have made some differences in some countries. It appears likely that this will happen in even more places, but by itself, this approach is likely to be insufficient.

Third, before industrial plants and firms in the developing market economies of East Asia can take advantage of cleaner production opportunities they must have the capability to acquire, install, adapt, and efficiently manage plant, equipment, technology, technical change, and technical knowhow. If industrial firms lack the capability to do these things, there may be significant limits to their ability to respond to regulatory, economy-wide, and industrial policy incentives designed to push them in a direction that lowers pollution, energy, water, and materials use intensities. Lack of capabilities in these areas might also limit the ability of firms to take advantage of new imported technologies that are cleaner. Currently, there is enormous variability within East Asia in the existing capabilities of firms to do this well (Chapter 2; Roberts and Tybout 1996; Kim 1997; Felker 1998; Rock 1995, 1999). This capability varies by country, by firm size, by sector, and by ownership. Firms in Northeast Asia appear to be better at this than their counterparts in Southeast Asia (Kim 1997; Felker 1998). Large firms appear to be better at this than small firms (Lall 1992: 169). This is easier for firms to do in supplier dominated capital goods sectors (textiles) than it is to do in either scale intensive sectors (automobiles or aircraft) or science-based sectors (such as chemicals or electronics where a strong capacity for reverse engineering is needed) (Bell and Pavitt 1992: 265). Firms engaged in joint ventures with large foreign firms appear to be better at this than domestically owned firms (Harrison 1996: 167–73).

Because there are significant externalities in the accumulation of production, technology, and technology capabilities, government policies are needed to speed the process by which firms acquire new technical capabilities and diffuse them throughout the economy (see Chapter 2 for a more detailed discussion). Policies that promote firm-level technical learning and capabilities acquisition are likely to be good for pollution, energy, water, and materials intensity reduction. They should make it easier for firms to engage in better housekeeping practices and minor process innovations that prevent pollution. They should make it possible for firms to 'stretch' existing plant and equipment by substantially modifying it to reduce pollution, energy, water, and materials use. They should also make it easier for firms to evaluate the pollution, energy, water, and materials intensity of 'new' imported plant, equipment, and technology. Because pollution, energy, water, and materials intensity reduction is or will be a relatively new activity for industrial firms in the developing economies of East Asia, industrial firms there are likely to need industry and technology specific information (and specialized technical training) on how to do this. This is just the kind of information and specialized training that institutions that are part of the national technology infrastructure (such as industrial technology institutes or standards agencies) are

good at providing. As we will argue in subsequent chapters (especially Chapters 2 and 3), they should be encouraged to provide such information and training to overcome information failures and the high transactions costs associated with reducing pollution, energy, water, and materials intensities. In addition, as we will also argue in Chapters 7 and 9, existing small and medium sized enterprises (SMEs) and multinational corporation (MNC) linkage programs aimed at technological upgrading of SMEs might well be modified to include MNC 'greening' of the supply chain programs (Battat *et al.* 1996).

What this adds up to, in sum, is the need for integration of industrial, technological, and environmental policy within the developing market economies of East Asia. Perhaps the greatest opportunity lies in the integration of policies aimed at the technological and industrial upgrading of economies—along the model pursued by the first tier newly industrializing economies of East Asia (Campos and Root 1996; World Bank 1993, 1998*b*)—with policies aimed at reducing the energy, materials, and pollution intensity of new industrial investment. We demonstrate in some detail how this has been accomplished in several of the East Asian NIEs in Chapter 3.

The central argument developed in this book is that getting policies right in three discrete but overlapping policy arenas—in environmental regulatory policy, in resources pricing policies, and in industrial, investment promotion, and technology policies—is critical to the success of cost-effective energy, materials, and pollution intensity reduction in developing economies. The chapters of this book demonstrate in some detail how individual countries in East Asia can use and have used these insights to design and implement cost-effective pollution intensity reduction policies. To begin with, as we demonstrate in Chapters 3 and 4, no improvement in environmental intensities is likely without the building of capable and well-resourced command and control regulatory agencies. But as we also show in Chapter 3, virtually all of these economies can gain by pricing energy, water, and materials closer to their real scarcity values. And as we demonstrate in Chapters 3, 5, 6, and 7, each of these economies can also gain by maintaining and increasing openness to trade, foreign investment, and foreign technology. But as we show in Chapter 2, these intensity reduction gains are not automatic. They must be combined with technology strategies, policies, and institutions that encourage firms to engage in high-speed technological learning and capabilities building, and by the integration of environmental, industrial, and technology policy. In addition, as we argue in Chapter 2, public investments in national technological capabilities building and incentives that reward individual firms for engaging in high-speed technological learning should also help firms move toward cost-effective pollution intensity reduction. Beyond this, policies need to be tailored to take advantage of differences in existing conditions in each of the economies of East Asia and in the rest of the developing world (Chapter 9).

2

Late Industrialization and Technological Capabilities Building

2.1 Introduction

How can governments and indigenous manufacturing firms in the rapidly industrializing economies of developing Asia take advantage of the opportunities afforded by the region's openness to trade and investment and its late industrialization to insure that urban industfrial development is more environmentally sustainable? As was argued in Chapter 1, our initial entry point for addressing this question is an understanding of the dynamics of technological upgrading and industrial capability building within the region. We begin here in large part because improvements in the energy, materials, and pollution intensity of industrial activity are fundamentally (though clearly not exclusively) an issue of technological change, of developing, deploying, and using product and process technologies that are less polluting. In addition, we anticipate that lessons learned from the ways in which the East Asian NIEs achieved rapid technological catch-up will be transferable to the problem of improving the environmental performance of industries within the region and within other developing economies. Specifically, we consider the institutional conditions and types of policy interventions that supported technological upgrading of firms and industries among the East Asian NIEs.

We begin with a review of what is known about industrial upgrading and technological catch-up as a development strategy, especially as practiced by the East Asian NIEs from the 1960s onwards. Our central conclusion is that institutions mattered. Through a review of existing studies, and through statistical analysis, we demonstrate that institutional effectiveness is a critical determinant of industrial competitiveness of developing economies. We also demonstrate that while there was no standard blueprint through which governmental institutions supported the work of firms, the institutional frameworks put in place within the East Asia NIEs were critical to their success in achieving rapid technology catch-up and industrial upgrading, and through these processes improved industrial competitiveness and industry-led economic growth.

2.2 Technological and Industrial Capacity Building

We begin, however, with the work of firms. Because most technological capabilities building requires effort, trial and error, and gaining tacit experience with particular technologies, it is primarily a task that only firms can undertake (Lall 1992: 166). As is now known, there are significant differences in the willingness of firms to undertake and succeed in these tasks. If this were not the case, productivity and efficiency differences between firms using the same technology in the same industry, both within and between countries, would be less than observed (Tybout 1996: 43–72). Differences in the degree to which firms in the same industry in the same country adapt and improve existing industrial technologies to new needs or create new comparative advantages in increasingly technology-intensive sectors would also be smaller than observed (Bell and Pavitt 1992: 257).

In developing countries, including the developing economies in East Asia, building firm-level technological capabilities is largely an imitative, rather than an innovative process. Firms in these economies most frequently build their technological capabilities by importing and adapting already existing technologies, rather than by engaging in basic research, applied research and development (R&D), or new product innovation. Firms in developing countries often start this process with very limited technological capabilities. Because of this, they face a particularly daunting set of problems and choices. To begin with, they must match their choice of foreign technology to local needs, conditions, and constraints (Dahlman *et al.* 1987: 762). Doing so requires firms to scan the technological horizon to identify and assess the technological possibilities open to them. This is a time-consuming and costly endeavor. For each possible choice, firms must assess the costs and benefits of that choice. This includes assessing the possibilities that each distinct technology holds for acquiring additional capabilities. Because different technologies offer substantially different opportunities for adaptation and improvement, initial technology choices tend to limit the capabilities that firms can acquire. Because it is difficult for firms to learn across diverse technological dimensions, particular technology choices also tend to move firms along particular technology trajectories. This means that initial technology choices and subsequent technological activity are very likely to be path dependent, thus making the initial technology choice decision doubly important.

Once firms have narrowed their search to particular technologies, they must decide precisely how to acquire all the elements—information, means, and understanding—associated with their technology choices (ibid. 767). Options include relying on foreign direct investment (FDI), technology licensing agreements, turnkey projects, purchase of individual pieces of capital equipment, and/or acquiring technological capabilities through technical assistance (ibid. 767–9). As might be expected, each option and/or

combination of options offers unique advantages and disadvantages. Having settled on technology choices and options for acquiring all the elements associated with particular technologies, firms must then invest in the arduous tasks of acquiring the investment, production, and linkage capabilities offered by the technologies they have chosen. With respect to investment capabilities, firms must learn how to organize and oversee all activities associated with establishing and/or expanding a given factory (Lall 1992: 171). This means they must be able to carry out investment feasibility studies of possible projects, develop training programs to impart particular skills, and learn how to make the technology work in a particular setting (ibid.). This normally involves adapting the technology to local conditions as well as choosing and supervising hardware suppliers and construction contractors.

Once the technology is installed, emphasis shifts to acquiring production capabilities, or the capability to improve the operation of the factory, to learn how to optimize operation of facilities, including raw material control, production scheduling, quality control, troubleshooting, and adaptation of processes and products to changing circumstances, and to repair and maintain equipment as needed (ibid.). Finally, firms must develop linkage capabilities that enable them to transmit information, skills, and technology to and receive information, skills, and technology and other inputs from component and raw material suppliers, subcontractors, and technology institutes (ibid.).

The work of Amsden (2001), Clark and Kim (1995), Dicken (2003), Scott (2002), Storper *et al.* (1998), and Yeung (1998) among others describes the dominant pathways to technological and industrial upgrading pursued by firms in late-industrializing economies, including the East Asian NIEs. In some cases, technological upgrading drew heavily upon downstream linkages and technological spillover effects accompanying foreign direct investment (Poon and Thompson 1998; Thompson 2002; UNCTAD 2001). In other cases, the prime pathway for technological learning came through participation in global supply chains (Fan and Scott 2003; Gereffi 1995; Humphrey and Schmitz 2002). And in still other cases, firms engaged in joint ventures and aggressive scanning and reverse engineering to identify, acquire, and master particular technologies (Kim 1997; Mardon 1990; Teubal 1996). As we have indicated, the mix of pathways used by firms in East Asia varied quite considerably across countries, and also changed over time as the capabilities of indigenous firms increased.

Economic geographers have insisted on a definite territoriality to these pathways to technological learning (see, for example, Clark *et al.* 2000; Storper 1997). A large literature now exists examining the degree to which proximity between buyers and suppliers is an important determinant of the success of inter-firm knowledge flows and of technological learning (see, for example, Gertler 1995). In many of the East Asian NIEs, such proximity between manufacturers and first tier suppliers was achieved as a largely

unintended outcome of an approach to attracting foreign investment that entailed the establishment of industrial estates that provided both high-quality infrastructure and tax incentives to firms locating there. Perhaps the classic example of this is the large number of electronics manufacturers and suppliers that were attracted to industrial estates in Penang, Malaysia (Johansson and Nilsson 1997). Beyond the proximity often sought between manufacturers and suppliers, economic geographers and others have emphasized the importance of agglomeration economies and territorially embedded learning within regions and among firms within the same industries located in close proximity in industrial districts (Asheim 2000; Maskell 2001). There is now a growing literature examining technological innovation and firm learning within such spatially concentrated industrial districts within developing economies (see, for example, Bell and Albu 1999; Schmitz and Nadvi 1999; Scott 1994). As occurred previously in the United States and elsewhere (Scott 1998), specialized industrial clusters have been an important part of the growth of 'new industrial spaces' in developing Asia. While there are a few studies that attempt to document qualitatively the existence of external economies within these industrial districts in developing Asia (see, for example, Liu 1998), much work remains to be done to assess and document the extent to which these external economies are contributing to technological catch-up and fast industrial capability building among indigenous firms, especially in China (Fan and Scott 2003).

What determines whether firms in developing countries are successful in participating in the global economy through one of these pathways of industrialization? And under what conditions do these pathways and their attendant economic geographies support accelerated technological learning and industrial capacity building on the part of indigenous firms? What are the pre-conditions needed for firms to be able to engage in the kinds of learning activities described above? Much of the literature suggests that getting the institutional and policy framework right at both the macro and meso levels is crucial to the success of firm-based technological learning. It is to this issue of the institutional pre-conditions for technological upgrading that we now turn. Our review begins with a consideration of the role of governments in creating the macro institutional conditions that are apparently required for firms in developing economies to have a strong prospect of success in industrial upgrading and capacity building within the global economy.

2.3 Macro Institutional Conditions

It is widely recognized that industrial technological catch-up policies and institutions offer the most promising way for developing economies to close the income gaps with their OECD counterparts. It is also well understood

that successful catch-up policies and institutions require focusing on the conscious efforts by individual firms and governments to assist firms in building their technological capabilities (UNIDO 2002*a*; Lall 1992; Dahlman *et al.* 1987). For their part, firms must commit substantial resources to a long-term, incremental, and cumulative, but difficult, uncertain, and risky effort to expand their technological capabilities (UNIDO 2002*a*: 93).

Governments can assist firms by maintaining political and macroeconomic stability, creating an institutional framework—including bureaucratic capabilities in government and an incentive system designed and implemented by capable and autonomous government agents—that encourages firms to engage in this difficult, risky, and costly process. Governments also need to ensure flexibility in factor markets and they must help firms to overcome market and coordination failures (ibid.). What this means is that neither a minimalist state nor just opening an economy to trade and foreign direct investment (FDI), as suggested by the Washington Consensus (World Bank 1993), is sufficient to ensure that indigenous firms in developing economies either build their technological capabilities or learn how to do so (ibid.).

Stated another way, institutions matter to the success of technological capability building by industrial firms in developing economies. In order to represent this point, we begin this section with a series of bi-variate scattergrams showing the simple correlation (or lack thereof) between a constructed measure of country industrial competitiveness and macroeconomic and political conditions. We recognize of course that these simple bi-variate plots are useful largely for their graphical representation. Later in the chapter we present a multi-variate statistical analysis of the institutional determinants of industrial competitiveness. To measure industrial competitiveness we use UNIDO's Competitive Industrial Performance (CIP) index. The CIP is an index that weights four variables—per capita value added in manufactures, per capita exports of manufactures, the share of medium and high tech manufactures in total manufactures, and the share of medium and high tech exports in export of manufactures—in an economy to construct an overall measure of the competitiveness of industry (UNIDO 2002*a*: 148).

Figures 2.1 and 2.2 present by scatterplot the relationship between the CIP index and two measures of a country's openness to trade and foreign investment, for a group of industrializing and industrialized economies. The countries used in the analysis are shown in Appendix 2A. As can be seen, these data show little direct correlation between openness and a country's industrial competitiveness. Our task therefore is to disentangle the institutions, conditions, and policies that intermediate between openness and industrial performance. What conditions support a country's ability to take advantage of openness and trade and investment and to leverage openness to technological upgrading, improved competitiveness of industry, and positive economic and social outcomes?

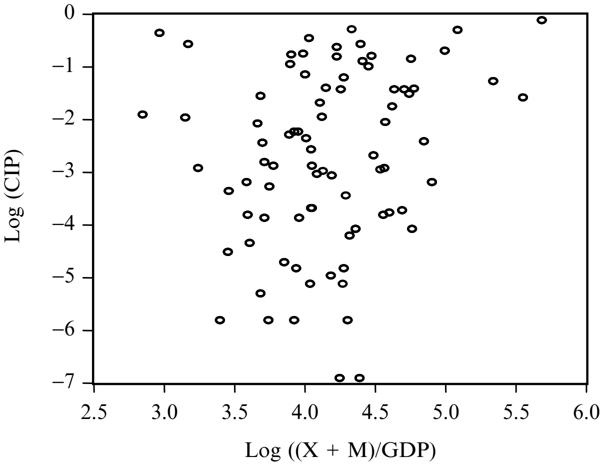

FIG. 2.1 Openness to trade (X + M)/GDP and UNIDO's CIP
Source: UNIDO (2002*a*) and World Bank (2004).

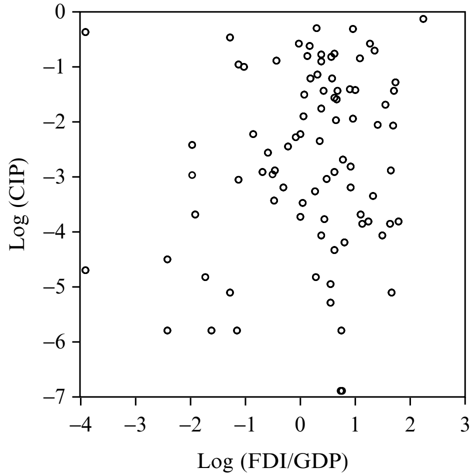

FIG. 2.2 Openness to foreign direct investment (FDI/GDP) and UNIDO's CIP
Source: UNIDO (2002*a*) and World Bank (2004).

Because all firms are embedded in a larger socio-political and economic environment in particular economies, government policies have an enormous impact on whether firms invest in building their technological capabilities, how much they invest in capabilities building, and how successful they are in building their capabilities. To begin with, governments must provide suffi-

cient political stability so that firms can reap the gains from long-term investments in building their technological capabilities. As Figure 2.3 suggests, political stability likely exerts a powerful influence on the degree to which firms in particular countries have successfully built their technological capabilities. Political instability shortens time horizons and encourages capital flight undermining firms' and countries' industrial competitiveness (see also Rock and Bonnett 2004). It turns out that macroeconomic stability—a competitive exchange rate and relatively low inflation—is equally important. If exchange rates are overvalued, firms find it difficult to be competitive in the global economy. This lowers returns to the linking, learning, and leveraging activities with outsiders in the global economy that firms must engage in to increase their technological capabilities. Graphical representation of this is provided in Figure 2.4, which shows the relationship between a country's CIP index and the degree of overvaluation of a country's exchange rate, as measured by the Dollar Index (Dollar 1992). Similarly, as can be seen in Figure 2.5, high and variable inflation rates, which distort relative prices and undermine the economic rationale for long-term investments by endangering economic growth (demand), also make it more difficult for firms to link, learn, and leverage their interactions with the global economy.

The competitiveness of industrial firms also depends on the quality and cost of infrastructural services—transport, communication, and power—and the availability of a requisite amount of skilled labor at the right wage rates. In most developing countries, governments exert a dominant influence on the cost,

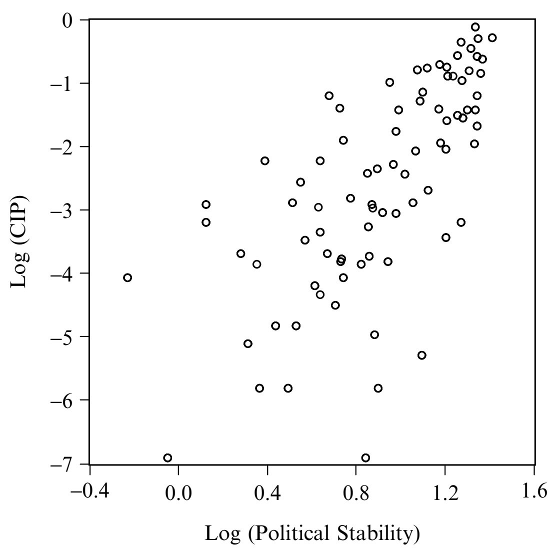

FIG. 2.3 Political stability and UNIDO's CIP
Source: UNIDO (2002*a*) and World Bank (2004).

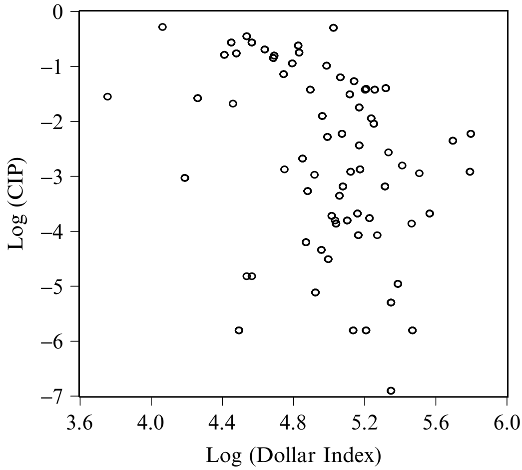

FIG. 2.4 Overvaluation of the exchange rate (Dollar Index) and UNIDO's CIP
Source: UNIDO (2002*a*) and Dollar (1992).

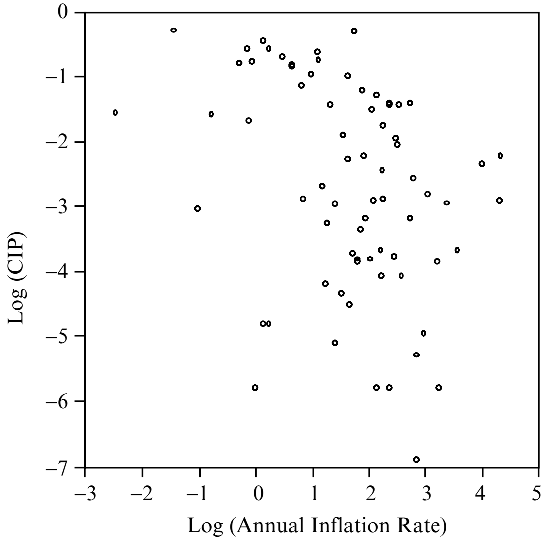

FIG. 2.5 Inflation and UNIDO's CIP
Source: UNIDO (2002*a*) and World Bank (2004).

quality, and supply of both physical infrastructure and skilled labor. If governments fail adequately to invest in infrastructure and skilled labor with the result that the cost of infrastructure and labor is too high or the quality and

reliability too low, firms find it difficult to compete in world markets. When this happens, as Figures 2.6 and 2.7 show, industrial competitiveness will be low.

Evans (1995), Evans and Rauch (1999), and Rodrik *et al.* (2002) have demonstrated that countries also need institutions—a set of formal and informal institutional arrangements for productive interaction between the public and private sector—and strategies to take advantage of economic openness—if they are to harness openness to trade and foreign direct investment to climbing the ladder of technology upgrading (Chang 2002). An integral part of this is the need to establish and sustain a long-term vision for industrial growth rooted in a linking, learning, and leveraging strategy for building technological capabilities that helps firms overcome market and coordination failures (UNIDO 2002*a*: 94). Failure to establish such a long-term vision undermines the credibility of governments' industrial policies, sending mixed signals to firms about whether their investments in capabilities building will be rewarded. Lack of a long-term vision for industrial development can result, and often has resulted, in the development of a wide range of dysfunctional support institutions. Chief among these are investment promotion agencies that offer promotional privileges based on corrupt rent-

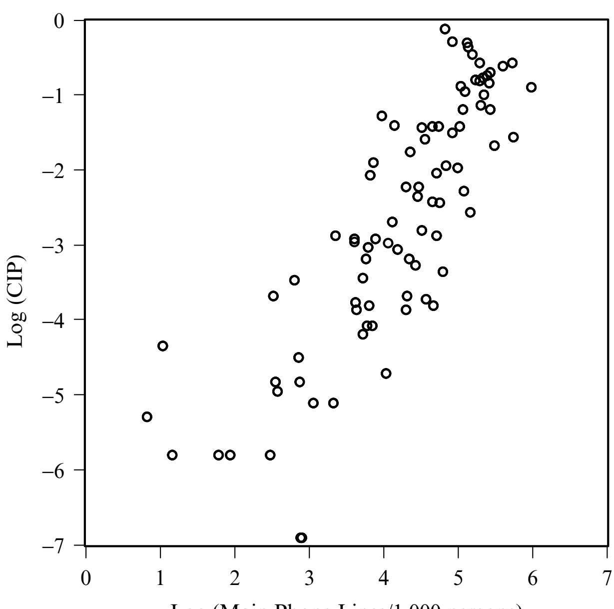

FIG. 2.6 UNIDO's CIP and physical infrastructure development (main telephone lines per thousand population)

Source: UNIDO (2002*a*) and World Bank (2004).

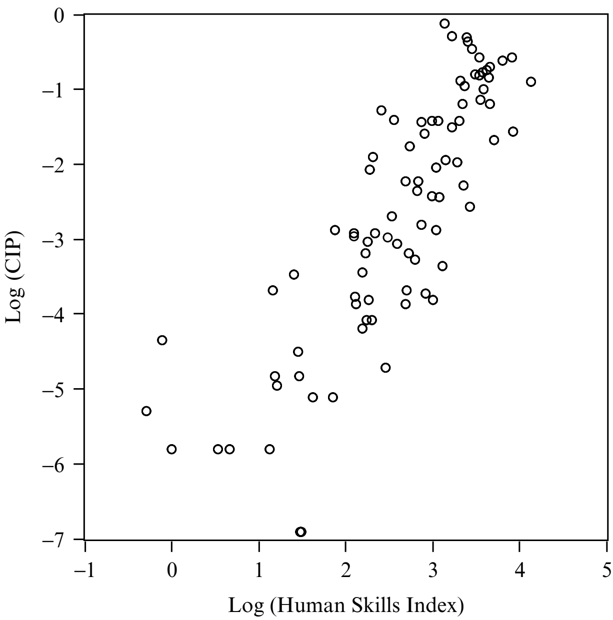

FIG. 2.7 UNIDO's CIP and human skills index
Source: UNIDO (2002*a*) and World Bank (2004).

seeking, rather than capabilities-enhancing, criteria. Similarly, when other industrial support institutions designed to help firms overcome information, market, and coordination failures—information service agencies, productivity centers, standards and metrology agencies, and extension services—are not linked to long-term visions of export-oriented industrial growth and embedded in strong networks with private sector firms or held accountable for results, they can end up providing services that are not in demand or needed by the private sector. The developing countries as a whole are overcrowded with examples of failed or failing industrial support institutions (UNIDO 2002*a*; Hobday 2002).

Most governments have difficulty providing the policies and institutions (suggested by Figures 2.1 through 2.7 and the accompanying narrative) needed to support technological learning and just as many, if not most, governments also have difficulty in developing and sustaining a long-term vision for industrial development rooted in technological upgrading. The experience in the East Asian newly industrializing economies suggests that these difficulties are likely to be related to the absence of a competent, relatively well-paid, development-oriented, and relatively non-corrupt bureaucracy. Creating such a bureaucracy is time consuming and costly (Evans and Rauch 1999; Evans 1995). It requires a merit-based recruitment system,

salaries that are comparable to those in the private sector, career ladders in government agencies that offer long-term opportunities for advancement, a public service problem-solving institutional *esprit de corps*, and embedded autonomy with the private sector (Evans and Rauch 1999: 749). As the literature on governance and bureaucracy attests and as Figure 2.8 shows, not surprisingly, bureaucratic competence is an important determinant of the competitiveness of a country's industries. When government bureaucracies fail to meet minimal requirements of bureaucratic competence, they are unable to provide firms with a long-run vision for industrial development and the stable incentive policies and effective institutions firms need to engage in the costly and risky process of building their technological capabilities. When this happens, firms under-invest in productive activity, including capabilities building, shift resources to rent-seeking activities, flee to the informal sector, and/or engage in capital flight.

2.4 Determinants of Industrial Competitiveness

As the scattergrams in Figures 2.1 through 2.8 and the accompanying narrative suggest, government policies across a number of different dimensions

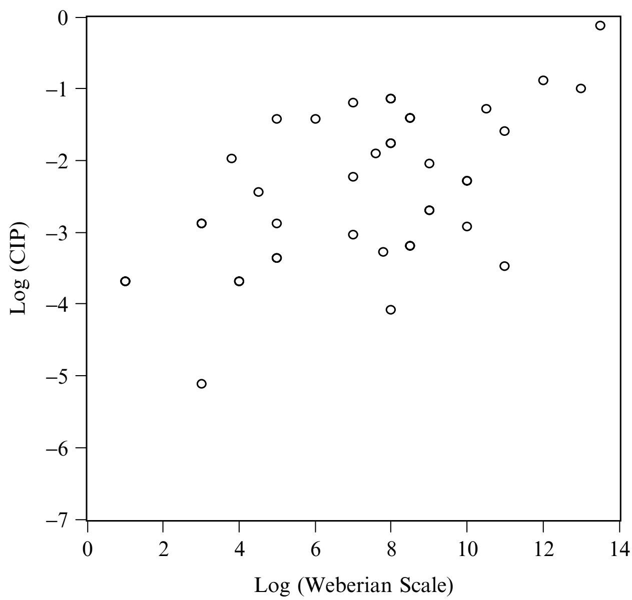

FIG. 2.8 Bureaucratic competence (Weberian Scale) and UNIDO's CIP
Source: UNIDO (2002*a*) and Evans and Rauch (1999).

exert powerful influences on the industrial competitiveness of countries. To more rigorously test the hypotheses linking these variables to the industrial competitiveness of countries, we adopt a framework based on the recent empirical literature on the relative roles of openness (Sachs and Warner 1995; Frankel and Romer 1999) and institutions (Rodrik *et al.* 2002; Dollar and Kraay 2002; Acemoglu *et al.* 2001) on development performance. Following Rodrik *et al.* (2002), we initially test for the impact of openness and institutions on a country's competitive industrial performance by estimating the regression equation: $CIP_i = \mathrm{a}_0 + \mathrm{a}_1\, INT_i + \mathrm{a}_2\, INST_i + e_i$ where CIP_i is UNIDO's CIP index, INT_i is a measure of a country's openness to the global economy, $INST_i$ is a measure of institutional quality, and e_i is the random error term. A country's trade share ($(X + M)/GDP$) is used to measure openness. The quality of a country's governmental institutions is measured by the Weberian Scale (WS) developed by Evans and Rauch (1999). This variable (WS) is multiplied by a dummy variable $D = 1$ if the country is thought to be more effective at promoting industrial development, and $D = 0$ otherwise.[1] $WS*D$ can be thought of as an effective government bureaucracy which promotes the industrial development variable. Because of endogeneity in our right-hand-side regressors, a two-stage least squares estimation procedure is employed. Instrumental variables come from a variety of sources. Following Hall and Jones (1999) and Dollar and Kraay (2002), institutions are instrumented with the fraction of a country's population that speaks a major European language (*EURFRAC*). Given the importance of a Germanic approach to government and industrial policy in East Asia (Johnson 1982), the variable *EURFRAC* is complemented by a dummy variable, *GERLEG*, where $GERLEG = 1$ if the country has a German legal tradition and $GERLEG = 0$ otherwise. Following Frankel and Romer (1999), integration is instrumented with a constructed trade share (*LFR*). Following Rodrik *et al.* (2002), geography (absolute value of latitude of a country's capital from the equator) is also used as an instrument in the expanded model equations (equations 3 and 4 in Table 2.1). To this basic equation, several additional variables, highlighted in Figures 2.1 through 2.7 and thought to affect a country's competitiveness, are added. These include a composite index of physical infrastructure and human capital (*TELHMINDEX*)[2] and a measure of macroeconomic stability (the dollar index).

Four regression equations are estimated by ordinary least squares (OLS) and two-stage least squares (TSLS). The first two equations are:

[1] We reviewed the published literature on each country in our sample to obtain a qualitative indication of whether the government in each country possessed and implemented a coherent industrial development strategy based on technological catch up.

[2] *TELHMINDEX* was constructed by converting our telecommunications variable and our human capital variable to indices and summing the indices.

TABLE 2.1. Regression equations: industrial policy and industrial competitiveness

Estimation procedure	OLS	TSLS	OLS	TSLS
Equation number	(1)	(2)	(3)	(4)
Dependent variables	*CIP*	*CIP*	*CIP*	*CIP*
Independent variables				
C	0.21	0.19	0.17	0.07
TRDY	0.001	0.001	0.0006	0.0006
	(2.98)***	(2.01)*	(1.65)	(1.11)
*WS*D*	0.019	0.019	0.017	0.011
	(5.31)***	(8.08)***	(4.07)***	(2.74)***
DOLLAR			−0.0002	0.0008
			(−1.11)	(0.48)
TELHMINDEX			0.002	0.003
			(3.26)***	(2.09)**
$\bar{R}^2$	0.67	0.63	0.75	0.61
Equation *F* statistic	29.62***	7.65***	21.96***	4.01**
N	28	28	28	28

Notes: Numbers in parentheses are *t* values. *** indicates significant at the 0.01 level. ** indicates significant at the 0.05 level. * indicates significant at the 0.10 level.
Estimation is with White's heteroskedasticity-consistent standard errors.
In TSLS regressions *TRDY* is instrumented with *LFR* and *WS*D* is instrumented with *GERLEG* and *EURFRAC*.

$$CIP_i = \mathrm{a}_0 + \mathrm{a}_1\ TRDY_i + \mathrm{a}_2\ WS_i{*}D_i + e_i$$

where *CIP* is UNIDO's CIP index, *TRDY* is the share of trade in GDP, WS^*D is the measure of the effectiveness of government at promoting industrial development and e_i is the random error term. This equation tests for the relative influence of openness and institutions on competitiveness. The third and fourth equations are given by

$$CIP_i = \mathrm{b}_0 + \mathrm{b}_1\ TRDY_i + \mathrm{b}_2\ WS_i{*}D_i + \mathrm{b}_3\ DOLLAR_i + \mathrm{b}_4\ TELHMINDEX_i + e_i$$

where $TRDY_i$, $WS_i{*}D_i$, and e_i are as defined in equation 1, $DOLLAR_i$ is our measure of macro-stability, and $TELHMINDEX_i$ is our composite physical infrastructure/human skills index. Because of possible endogeneity between the government support for the industrial development variable and several of the right-hand-side variables, equations 2 and 4 are estimated by two-stage least squares (TSLS), while equations 1 and 3 are estimated by ordinary least squares (OLS).

In the base OLS and TSLS regression equations (equations 1 and 2), which test for the relative influence of openness and institutions on competitiveness, the institutions variable is statistically significant in both equations at the

0.01 level with the expected sign (positive) and the openness variable is statistically significant at the 0.01 level in the ordinary least squares equation (equation 1) with the expected sign, but it is only significant at the 0.10 level (with the expected sign—positive) in the two-stage least squares equation. The adjusted R^2 for each equation is quite high (0.67 for equation 1 and 0.63 in equation 2) and the equation F tests reveal that both equations are statistically significant at the 0.01 level.

Turning to the expanded model (equations 3 and 4 in Table 2.1) neither the trade variable (*TRDY*) nor the macroeconomic stability variable (*DOLLAR*) is statistically significant. On the other hand, the composite physical infrastructure/human skills index variable (*TELHMINDEX*) is statistically significant with the expected sign at either the 0.01 level (equation 3) or the 0.05 level (equation 4), while our industrial policy/institutions variable (*WB**D*) is statistically significant at the 0.01 level with the expected sign in both equations. Adjusted R^2 is high in both equations (0.75 in equation 3 and 0.61 in equation 4) and equation F statistics reveal that the ordinary least squares equation is statistically significant at the 0.01 level and the two-stage least squares equation is statistically significant at the 0.05 level. While this set of findings may appear surprising to some, it is consistent with that in Rodrik *et al.* (2002: 31) who find that in a two-stage least squares (TSLS) regression of real GDP per capita on openness and institutions, institutions 'trump . . . openness' (ibid. 8).

Taken together, these findings offer powerful support for our claim that effective institutions are a critical driver of industrial competitiveness. But some might argue that our industrial policy/institutions variable does not capture directly government support for the technological upgrading activities of indigenous firms. To compensate for this shortcoming, we took advantage of a very strong statistical relationship between two firm-level technological upgrading variables (firm-level spending on research and development as a share of GDP (*RDY*) and firm-level royalty payments as a share of GDP (*RY*) and our industrial policy/institutions variable (*WS**D*) to incorporate technological learning into our industrial policy/institutions variable.[3] We did so simply by multiplying our industrial policy/institutions variable (*WS**D*) by the sum of *RDY* and *RY*. We label this new variable *GSTU* or government institutional support for firm-level technological upgrading by private sector firms. We then re-estimated the two-stage least squares equations in Table 2.1. We also estimated a new equation given by $GSTU_i = c_0 + c_1\ TRDY_i + c_2\ DOLLAR_i + e_i$. This equation allows us to test

[3] In a two-stage least squares regression on firm-level technological learning ($RDY + RY$) with the full set of independent variables listed in Table 2.1 only our institutions variable (*WS**D*) was statistically significant. In a two-stage least squares equation of institutions on firm level investments in learning ($RDY + RY$), the estimated equation is given by $RDY + RY = 0.20 + 0.197\ WS{*}D$ with a t value for the coefficient on $WS{*}D$ of 14.80 which is significant at the 0.01 level. This equation has an adjusted $R^2 = 0.69$ and an equation $F = 25.56$.

TABLE 2.2. Regression equations: industrial policy support for technological upgrading by firms and industrial competitiveness

Estimation procedure	TSLS	TSLS	TSLS
Equation number	(1)	(2)	(3)
Dependent variables	*CIP*	*CIP*	*GSTU*
Independent variables			
C	0.21	0.10	−9.92
TRDY	0.0008	0.0004	0.07
	(1.48)	(0.85)	(1.76)*
GSTU	0.007	0.004	
	(11.29)***	(2.69)***	
DOLLAR		0.0006	0.076
		(0.39)	(0.65)
TELHMINDEX		0.002	
		(1.65)	
$\bar{R}^2$	0.61	0.57	0.19
Equation *F* statistic	7.52***	3.61**	1.39
N	28	28	28

Notes: Numbers in parentheses are *t* values. *** indicates significant at the 0.01 level. ** indicates significant at the 0.05 level. * indicates significant at the 0.10 level. Estimation is with White's heteroskedasticity-consistent standard errors. In TSLS regressions *TRDY* is instrumented with *LFR* and *GSTU* is instrumented with *GERLEG* and *EURFRAC*.

for the indirect effects of our variables of interest on competitiveness through their impact on government support for the technological upgrading activities of firms. The results appear in Table 2.2. They confirm our early findings that institutional support for technological upgrading and investment in physical infrastructure/human skills development are the primary determinants of industrial competitiveness. They also show (in equation 3) that openness to trade operates as a handmaiden to government support for technological learning within firms, rather than acting directly on industrial competitiveness. The results also confirm that government support for technological activity exerts a powerful influence on the industrial competitiveness of countries. But these findings raise the question: how did the successful late industrializers in East Asia achieve critical mass in technological capabilities?

2.5 Experiences of East Asia's Developing Economies with Capabilities Building

In the previous section we presented statistical evidence suggesting that institutional effectiveness across a variety of domains, from the capacity to fund infrastructure and investments in education to control of corruption,

matters to a country's ability to promote industrial competitiveness and industrial capability building by firms in developing countries. But to this point our analysis remains relatively abstract. To be useful in guiding future policy interventions we need to know more specifically the ways in which governments in the East Asian NIEs were able to establish both the macro and meso conditions required for rapid technological and industrial capability building.

Asked another way, how did the successful industrializers in East Asia in the post-World War II period meet a demanding set of conditions for technological capabilities building? We answer this question by describing three distinct, but overlapping, pathways to capabilities building in East Asia. In the first instance, the core features of each pathway are identified. Subsequently, how core and non-core elements were combined to generate critical mass in capabilities building is demonstrated.

The first pathway, followed by Taiwan Province of China, focused on the building of the public sector institutions of a national technology system that were tightly linked through embedded autonomy to the country's small and medium sized enterprises (SMEs) and the international economy (Wade 1990). A public sector investment promotion agency identified industries and technologies thought to be most applicable to each stage of industrial development in Taiwan Province of China (Wade 1990: 199–206). A quasi-public quasi-private sector science and technology institute acquired these technologies, reverse engineered them, and either spun them off or diffused them to the country's numerous SMEs (ibid. 98–107). A public sector export-marketing agency helped these firms overcome information failures associated with serving markets of developed countries (Keesing 1988; Wade 1990: 146–9). Another public sector agency linked the country's larger firms to clusters of smaller firms that ultimately became suppliers to these larger firms. In numerous instances, state-owned enterprises in upstream industries were used to acquire technological capabilities in scale-intensive industries and to supply downstream users with high quality and competitively priced intermediate inputs (Wade 1990: 202).

A second pathway, followed by the Republic of Korea (Amsden 1989), and, to a lesser extent, by governments in Indonesia (Rock 1999) and Thailand (Rock 1995 and 2000), focused on new government institutions and new incentives for building large indigenous national firms that could compete with developed country MNCs. The approach of the Republic of Korea to building technologically competent national firms was rooted in a unique institutional framework that enabled the government to allocate performance-based promotional privileges, particularly subsidized credit from state-owned banks, to a small number of what turned out to be very large conglomerates (Amsden 1989; Jones and Sakong 1980; Rhee *et al.* 1984; Westphal 1981). Those firms also relied heavily on the government's Foreign Capital Inducement Act, which severely restricted foreign direct

investment and rigorously reviewed these firms' requests for licensing and technical assistance agreements so as to ensure that such agreements hastened the building of firm-level technological capabilities (Mardon 1990). Governments in Thailand and Indonesia were less capable than their counterparts in the Republic of Korea and government–business relationships were more prone to rent-seeking activities (Rock 1995, 1999, 2000; MacIntyre 1994, 2000). Governments in both countries were also more open to foreign direct investment. Because of this, promotional privileges tended to be somewhat less performance based. Despite this fact, governments in both countries targeted promotional privileges to a relatively few, in what turned out to be very large national firms engaged in joint ventures with large developed country multinational corporations (Rock 1999, 2000). As in the Republic of Korea, those firms dominated the industrial economy. Initially, many of the joint ventures between these large national firms and multinational corporations served local markets rather than export markets. But over time, promotional privileges shifted to encourage the export of manufactures.

Both these pathways were rooted in an assumption that capabilities building required the creation of indigenous industrial entrepreneurs who would link to, learn from, and leverage their ties with the global economy. Each was also predicated on an assumption that the government would have to use incentives to create an indigenous class of entrepreneurs. The last pathway, a pathway followed by Singapore and Malaysia, initially focused on creating an institutional framework and developing the physical and human infrastructure necessary to attract multinational corporations from developed countries (Lee 2000: 56; Times Academic Press 1993; Rasiah 1995). In both countries, premier investment promotion agencies scoured the globe for firms and industries to attract. In both countries, first world industrial parks, and export processing zones (EPZs) and licensed manufacturing warehouses (LMWs), were built to meet foreign investors' needs for reliable, high quality, and reasonably priced infrastructure services. Both countries also invested heavily in skilled labor, controlled wage rates, and severely restricted workers' rights to unionize and strike (Jomo and Todd 1994). In the first instance, this approach to capabilities building did not assume the necessity of creating an indigenously owned industrial base or an indigenous class of entrepreneurs. Subsequently, governments in both Singapore and Malaysia extended this model to include the participation of indigenous small and medium sized enterprises (SMEs) in the global value chains of multinationals located in each economy (Battat *et al.* 1996; Rasiah 2001). In both instances, this was accomplished through local industry upgrading programs or vendor development programs that linked investment promotion agencies, multinationals, and local supplying SMEs in long-term relationships that enabled local supplying firms to meet the quality, price, and on-time delivery specifications of their multinational buyers. Along the way, the various local small and

medium sized firms supplying the multinationals with various intermediate inputs acquired substantial technological capabilities. Variants of these models can be found elsewhere in the developing countries.

In each of these cases, the governments were staffed by increasingly capable bureaucracies that adopted long-term visions of industrial growth, maintained political and macroeconomic stability, kept factor markets flexible, provided institutional frameworks and governance structures that incited entrepreneurs to invest and take risks, financed and/or provided high-quality infrastructure and an increasingly skilled labor force, and built high-quality support institutions deeply embedded in the private sector (World Bank 1993). But in each instance none of this was easy to achieve. To begin with, capable government bureaucracies had to be created and sustained. Since none of the reform-minded governments that led new industrial development strategies inherited well-developed and capable bureaucracies, creating them was a difficult, time-consuming, and costly process.

Simultaneously with the development of bureaucratic capabilities, governments learned in long, pragmatic, often tortuous, trial and error processes how to deal with numerous other issues required to bring their visions of industrial development to fruition. In no case did governments develop and follow a well-defined blueprint, such as the Washington Consensus. In virtually every case, political and macroeconomic stability followed a period of instability in one or both. After re-establishing political and/or macroeconomic stability, new political leaders figured out how, with the help of their advisors, to take advantage of political and/or economic crises to create a new political economy of growth around industrial development and the export of manufactures. This meant that political leaders found ways to link their newly created visions for industrial development to their long term political needs.[4] Without this, it is doubtful that they would have developed and/or sustained their commitments to industrial development.

In countries with large agricultural populations, modernization of smallholder food crops (rice) proved to be an important and critical catalyst to industrial development strategies. Some (Grabowski 1994) have argued that East Asia's developmental states originated in agriculture. Others (Kay 2002; Johnston and Mellor 1961; Mellor and Johnston 1984; Johnston and Kilby 1975; Murphy *et al.* 1991; Erh-Cheng 1988; Timmer 1993; Rock 2002*c*) have argued that successes in smallholder agriculture stimulated industrial development by increasing local incomes and the demand for manufactures, reducing poverty, freeing labor for urban industrial work, and either earning foreign exchange or freeing foreign exchange from having to import food. Heavy investment in education, particularly primary education and subsequently in secondary, tertiary, and engineering education, was equally critical (Haggard 1990; Campos and Root 1996:

[4] For examples of this in Indonesia see Rock (2003) and for Korea see Kang (2002).

56–60). Without either, it is doubtful whether these countries would have been able to provide industrial investors with sufficient quantities of unskilled, semi-skilled, and skilled labor at the right prices that were needed to make their investments profitable.

Establishing the incentives and institutions for long-term industrial development and technological capabilities building was also a long and protracted process. To begin with, each of these governments established and maintained flexible factor markets, particularly for labor, more often than not by repressing unions and passing and enforcing very tough anti-union legislation. Governments in each of these countries also created unique incentive structures and institutions to promote industrial development. The government of the Republic of Korea relied on administrative allocation of heavily subsidized credit from state-owned banks, a centralized performance-based export targeting system, and tight control over FDI and licensing and technical assistance agreements to stimulate the chaebol to engage in high-speed technological upgrading. Taiwan Province of China used state-owned enterprises in upstream industries, an aggressive industrial promotion agency, a highly capable science and technology institute to acquire technological capabilities from abroad, reverse engineer them, and diffuse them to a large number of relatively small firms, and a public sector export marketing agency to market exports in developed countries. Investment promotion agencies and the large promoted indigenous firms in Indonesia and Thailand relied on lucrative promotional privileges, local content provisions in investment promotion agreements with foreign joint venture partners, requirements that indigenous firms be majority partners with foreign joint venture firms, explicit technology transfer requirements, and incessant pressures from governments and promoted firms to get foreign multinationals to transfer technologies to their joint venture partners. Governments in Singapore and Malaysia offered substantial promotional privileges, excellent infrastructure facilities, and a highly skilled labor force to get MNCs to locate there. Over time, both governments learned how to calibrate promotional privileges to attract higher value-added operations and to link local SMEs to the international production networks of the multinationals.

Along the way, governments in these countries built and sustained industrial support institutions tightly linked to the needs of the private sector. The Republic of Korea and Taiwan Province of China built successful export marketing agencies (Rock 1992; Keesing 1988). Taiwan Province of China also created a premier high-technology industrial park and a highly successful science and technology institute (Wade 1990). Both, along with Indonesia, Malaysia, Singapore, and Thailand, relied heavily on industrial parks and export processing zones (EPZs) to site either many of the joint venture activities between local and foreign firms or the activities of promoted foreign firms. Governments in virtually all these countries created enormously successful investment promotion agencies. In the

Republic of Korea, Taiwan Province of China, Singapore, and, to a lesser degree, Malaysia, investment promotion agencies acted as one-stop investment shops and regularly targeted particular foreign firms and industries for promotional privileges. In Indonesia and Thailand, investment promotion agencies were less successful at industrial targeting and more prone to rent seeking. Nevertheless, investment promotion agencies in both were very successful at showering the bulk of promotional privileges on a small number of firms that grew to dominate the industrial economy (Rock 1995, 1999).

As the above narrative suggests, the East Asian NIEs used a rich and diverse array of policies and institutions to promote industrial capability building. Table 2.3 summarizes these specific policy tools and highlights the ways in which specific policies were used by East Asian NIEs. For heuristic purposes, Table 2.3 identifies three pathways for industrial capability building and the use of specific policy instruments in each of these pathways. The three pathways considered are those of building indigenous industrial capability through joint ventures among domestic and foreign large firms, building a national technology system and linking that system to the capability building of small and medium sized enterprises, and third, promoting the participation of small and medium sized firms as suppliers within global value chains. We recognize of course that each of the Asian NIEs combined these pathways in various ways. It is helpful, however, to recognize that there are different industrial pathways that can be promoted based on the situation in different countries.[5]

Despite the institutional and policy diversity exhibited in Table 2.3, several commonalities bear mentioning. To begin with, a close examination of the table suggests that, with limited exceptions, most of the technological policies/institutions were used in each of the pathways for technological upgrading. Thus, what distinguished the use of a particular policy/institution was not whether or not a policy or instrument was used, but rather its targeted focus on a particular pathway. For example, the Republic of Korea, and to a lesser extent Indonesia, Malaysia, and Thailand, used most of its policy/institutions to promote high-speed technological learning in large-scale indigenous conglomerates. Taiwan Province of China used most of its policies/institutions to link its institutions of national innovation to technological changes occurring in the global economy and to the large number of indigenous export-oriented SMEs. In Singapore and Malaysia, particularly in export-oriented manufacturing sectors, both used their policies/institutions to promote linkages between indigenous SMEs and the global value chains of OECD-based MNCs.

[5] We return to this point in Chapter 10 when we consider the opportunities for industrial capability building and policy integration in low income economies.

In addition, as the case studies of technological upgrading experiences of the East Asian newly industrializing economies (Hobday 1997; Rhee *et al.* 1984; Kim 1997; Amsden 1989; Wade 1990; Huff 1999; Mani 2000; Goldman *et al.* 1997; Felker and Jomo 1999; Arnold *et al.* 2000; and Evans 1995) and Table 2.3 demonstrate, much more is required of governments than merely getting underlying non-technological development policies (macroeconomic stability, physical infrastructure and human skills, and an effective and goal-oriented governmental bureaucracy) right. Owing to market and coordination failures, learning externalities, and increasing returns associated with the development and use of various technologies (Chang and Cheema 2001: 18–21), successful technological development requires the development and implementation of a set of explicit policies and institutions to facilitate technological learning in private sector firms. While elements of these technological policies and institutions appear in many places in developing countries, they have been most successful in the first and second tier East Asian newly industrializing economies (Westphal 2001: 7).

2.6 Assessing the Contribution of Policies and Institutions to Technological Upgrading

Our review of the technological policies and institutions identified in Table 2.3 also indicates that the governments in East Asia recognized the central role of firms in technological development. Because of this, industrial, trade, credit, and infrastructure policies for technology development focused on a very wide range of policies designed to increase firms' demand for technological development and the flow of technology and people between firms by promoting the export of manufactures (Westphal 2001: 38). In fact, these demand-increasing, market-building (Justman and Teubal 1995: 267), and export-oriented incentive policies, which stimulated firms' demand for other firms' technology and for increasingly skilled people, were the *sine qua non* of successful technological upgrading policies in East Asia.[6]

Demand-increasing incentive policies[7] were frequently combined with the development of technology support institutions (see Table 2.3) designed to increase the supply of technology to firms in developing countries. Limited available evidence suggests that these institutions have generally been less successful in promoting technology upgrading than demand-stimulating incentive policies (Arnold *et al.* 2000). This is particularly so when they operate in the absence of strong demand-increasing policies, when they are divorced from the real needs of firms, or when they focus on supplying

[6] In our view, Westphal (2001) argues this most forcefully and convincingly.

[7] We prefer the term demand-increasing incentive policies over the term incentive policies because it indicates the importance of stimulating firm-level demand for technology.

TABLE 2.3. Technology policies and institutions used for different pathways to technological upgrading in East Asia

Policy/institution	Objective	Pathway to technological upgrading		
Demand-increasing industrial policies	Rationale for policy and/or institution	Building large-scale domestic conglomerates	Building a national technology system linked to local SMEs and the global economy	Linking local SMEs to the global value chains of multinational corporations
Board of Investment promotional privileges sometimes targeted at promoted firms in promoted industries	Assumes that tax holidays and accelerated depreciation are required to get firms to invest in capital equipment and new technology. Sometimes used to encourage promoted firms (local and foreign) in promoted industries to invest in new capital equipment and sometimes to undertake R&D. Overriding objective is to increase productive investment in promoted firms and industries	Used by the Republic of Korea (Rhee *et al.* 1984 and Jones and Sakong 1980) to build export-oriented firms and by Indonesia (Rock 1999), Malaysia (Felker 2001), and Thailand (Rock 1995) to build large local import substitution firms that ultimately became export oriented	Used by Taiwan Province of China (Wade 1990) to build export-oriented SMEs	Used by Singapore and Malaysia to attract OECD-based multinational corporations (Mani 2000)
Infrastructure provision sometimes for promoted firms in promoted industries, particularly in industrial estates, EPZs, and licensed manufacturing warehouses. Often linked to export	Reliable infrastructure—power, water, wastewater treatment, roads, ports and airport facilities—is typically lacking or is of poor quality in many developing countries. Provision of high-quality in-	Used by the Republic of Korea (Rhee *et al.* 1984)	Used by Taiwan Province of China (Wade 1990)	Used by Singapore (Huff 1999) and Malaysia (Churchill 1995) to attract OECD-based multinational corporations

performance requirements	frastructure reduces the cost of business and can be used to attract FDI and increase profitability of investments made by local firms. Is often used to promote the exports of promoted firms in promoted industries. Objective is to enhance quality of infrastructure			
Public investment in education (primary, secondary and tertiary) and training initially imparting basic skills for low-skilled workers, but focusing over time on skilled workers. Sometimes (as in Ireland) after formal schooling, workers are trained in a national training agency. Other times, government support is used to fund in-company training. In several countries (Malaysia, Republic of Korea, and Singapore) in-company training funded by a levy on firms that is reimbursable for in-company training expenses	Insures a sufficient supply of increasingly skilled workers that meets the needs of industrial firms at acceptable wages to foreign and local firms. Objective is to enhance the quality and quantity of educated labour for use in manufacturing	Used in the Republic of Korea (Haggard 1990) and to a lesser extent in Malaysia (Mani 2000) and Thailand (Arnold *et al*. 2000)	Used by Taiwan Province of China (Haggard 1990)	Used by Singapore (Huff 1999 and Mani 2000) and Malaysia (Mani 2000) to attract OECD-based multinational corporations

(*Continued*)

TABLE 2.3. Technology policies and institutions used for different pathways to technological upgrading in East Asia (*Continued*)

Policy/institution	Objective	Pathway to technological upgrading		
Demand-increasing industrial policies	Rationale for policy and/or institution	Building large-scale domestic conglomerates	Building a national technology system linked to local SMEs and the global economy	Linking local SMEs to the global value chains of multinational corporations
Regulating and limiting new firm entry into a promoted industry. Promoting formation of government-sanctioned cartels	Enables promoted firms in a promoted industry to capture rents. Also justified as necessary to thwart 'excess competition'	Used in the Republic of Korea (Jones and Sakong 1980), Indonesia (Rock 1999), and Thailand (Rock 1995)	Used in Taiwan Province of China (Wade 1990)	Not used
Government procurement of the output of promoted firms in promoted industries	Increases demand for the output of promoted firms in promoted industries. May be necessary for promoted firms to be able to overcome increasing returns to scale problems	Used in the Republic of Korea (Amsden 1989)	Used in Taiwan Province of China (Wade 1990)	Not used
Creation of state-owned enterprises in new industries where risks are assumed to be too large for private sector firms to undertake	Enables entry into an industry where capital investments and risks are high	Used in the Republic of Korea (Amsden 1989), Indonesia (McKendrik 1992), and Malaysia (Felker and Jomo 1999)	Used in Taiwan Province of China in upstream industries (Wade 1990)	Not used
Directed and subsidized credit	Enables promoted firms in promoted sectors to expand production capacity and technological capabilities	Used in Indonesia (Rock 1999) and the Republic of Korea (Rhee *et al*. 1984)	Used in Taiwan Province of China (Wade 1990)	Not used
Joint public–private sector deliberation councils	To increase the demand in local firms for technology development by limiting access of foreign firms in certain sectors (both import substituting and export-oriented) and/or	Used in Indonesia (Rock 2002*a*), Malaysia (Jomo and Todd 1994), Republic of Korea (Haggard 1990), and Thailand (Rock 1994)	Used in Taiwan Province of China (Haggard 1990)	Used in Singapore (Huff 1999) and Malaysia (Jomo and Todd 1994)

	requiring foreign firms to transfer explicit technologies and/or develop a local (indigenous) supplier base			
Labor market regulations that limit coverage of minimum wage legislation, restrict efforts to unionize, and ban or limit the right to strike, particularly in EPZs and licensed manufacturing warehouses	Keeps manufacturing wages nearer to market levels and limits disruption to production by union activity and strikes. Helps keep labor costs down thereby enhancing corporate profits	Used most extensively in the Republic of Korea (Rhee *et al.* 1984 and World Bank 1993), less so in Malaysia (Felker 1999) and Thailand (Rock 1995)	Used extensively in Taiwan Province of China (Wade 1990)	Used extensively in Singapore (Huff 1999; Mani, 2000; and Battat *et al.* 1997) and in Malaysia, particularly in Penang (Churchill 1995)
Venture capital development programs	Assumption is that market failures of high-tech industries limit emergence of domestic high-tech entrepreneurs. Subsidies and low interest loans plus incentives to get high-tech personnel to move from public sector high-tech R&D agencies to start own venture capital firms. Objective is to stimulate investment and risk taking in high-tech industries	Used in the Republic of Korea (Teubal 2002)	Used in Taiwan Province of China (Wade 1990)	Used in Singapore after 1991 (Mani 2000)
Indicative planning, sometimes (as in the Republic of Korea and Taiwan Province of China) used to monitor and reward/punish firms for meeting or failing to meet quantitative export targets	Indicative planning when tied to performance monitoring of firm-level performance and subsequent allocation of learning rents based on performance relevant to target can be a powerful way for the state to hold firms accountable for technological learning. Objective used to hold firms accountable for performance	Used in the Republic of Korea (Rhee *et al.* 1984)	Used in Taiwan Province of China (Wade 1990)	Not used

(Continued)

TABLE 2.3. Technology policies and institutions used for different pathways to technological upgrading in East Asia (*Continued*)

Policy/institution	Objective	Pathway to technological upgrading		
Demand-increasing industrial policies	Rationale for policy and/or institution	Building large-scale domestic conglomerates	Building a national technology system linked to local SMEs and the global economy	Linking local SMEs to the global value chains of multinational corporations
Import protection provided to promoted industry via import bans, import quotas, and high and variable effective rates of protection	Increases demand for the output of promoted firms in promoted industries. May be necessary for promoted firms to be able to overcome increasing returns to scale problems	Used in Indonesia (Rock 1999), Republic of Korea (Jones and Sakong 1980 and Rhee *et al*. 1984), and Thailand (Rock 1995)	Used in Taiwan Province of China (Wade 1990)	Not used in Singapore or in export activities in Malaysia
Export subsidies provided to promoted firms in promoted industries	Increases demand for the output of promoted firms in promoted industries. May be necessary for promoted firms to be able to overcome increasing returns to scale problems	Not used	Some used in Taiwan Province of China (Wade 1990)	Not used
Preferential access to foreign exchange, sometimes at preferential rates particularly for exports	Increases the demand for exports of promoted firms in promoted industries. May be necessary for promoted firms to be able to overcome increasing returns to scale problems	Used in the Republic of Korea (Rhee *et al*. 1984)	Used in Taiwan Province of China during the early days of its export drive (Wade 1990)	Not used
Duty drawback privileges on tariffs and taxes on imported inputs for exports of promoted firms in promoted industries	Used to overcome the import bias in the trade regime	Used in Indonesia (Rock 1999), Republic of Korea (Rhee *et al*. 1984; Westphal 1987), and Thailand (Rock 1995)	Used in Taiwan Province of China (Wade 1990)	Used in export activity in Malaysia (Churchill 1997), not used in Singapore

Control over access to imported raw materials and spare parts used to produce exports	Given foreign exchange constraints, allocating imported raw material and spare parts to those who use these inputs to export makes it possible for exporters to meet export demand	Used most extensively in the Republic of Korea (Rhee *et al.* 1984)	Used in Taiwan Province of China (Wade 1990)	Not used
Widely publicized national annual export award programs administered by the highest level of political authority	National publicity and high-level political support for firm-specific export performance increases the demand for technological capability needed to increase exports	Used in the Republic of Korea (Rhee *et al.* 1984)	Used in Taiwan Province of China (Wade 1990)	Not used
Joint public–private local industry upgrading programs linking foreign and export-oriented multinational corporations or large/medium sized export-oriented domestic firms with local SMEs	Local SMEs lack the technological and managerial capabilities to meet the price, quality, and on-time delivery needs of foreign export-oriented multinationals and large export-oriented local companies. Objective of local industry upgrading programs is to overcome these problems	Not used in the Republic of Korea or Indonesia, used but believed not to be successful in Thailand (World Bank 1990)	Used in Taiwan Province of China, particularly for larger local firms and local SMEs in industrial parks in center-satellite systems (Battat *et al.* 1996)	Used in Singapore (Battat *et al.* 1996) and in Malaysia (Churchill 1995) in export activity
Creation of a public sector export marketing agency	Assumption is that local firms have difficulty identifying potential export markets. This limits demand for their exports. Objective is to use a public sector export marketing agency to help local firms identify foreign market demands	Used in the Republic of Korea (Keesing 1988) and Thailand (McKean *et al.* 1994)	Used in Taiwan Province of China (Keesing 1988)	Not used

(*Continued*)

TABLE 2.3. Technology policies and institutions used for different pathways to technological upgrading in East Asia (*Continued*)

Policy/institution	Objective	Pathway to technological upgrading		
Demand-increasing industrial policies	Rationale for policy and/or institution	Building large-scale domestic conglomerates	Building a national technology system linked to local SMEs and the global economy	Linking local SMEs to the global value chains of multinational corporations
Public sector export quality testing institutes	In the Republic of Korea and Taiwan Province of China, there was a fear in the public sector that local firms would not be able to meet buyers' quality requirements. This fear was stoked by Japan's early experience as an exporter of low-quality toys and trinkets	Used in the Republic of Korea (Rhee *et al.* 1984)	Used in Taiwan Province of China (Wade 1990)	Not used
Technology supply-enhancing institutions/incentive policies		Building large-scale domestic conglomerates	Building a national technology system linked to local SMEs and technological changes in the global economy	Linking local SMEs to the global value chains of OECD-based multinational corporation
Ministries of Science, Technology and the Environment, National Science and Technology Agencies/Boards	Charged with spearheading and coordinating national policies with regard to science and technology and research and development. Objective is to identify science and technology needs of industrial firms and find ways to meet these needs by engaging, among other things, in scientific and technological research	Used in Malaysia (Mani 2000) and Thailand (World Bank 1990)	Used in Taiwan Province of China (Wade 1990)	Used in Singapore (Mani 2000) and Malaysia (Mani 2000)

Premier national science and technology agencies	Assumption is that indigenous firms are not likely to be innovators. Proposed solution is to have innovation and research and development undertaken by a public sector S&T or R&D agency	Used in Indonesia (McKendrik 1992), Malaysia (Mani 2000), Republic of Korea (Lee *et al*. 1991), and Thailand (World Bank 1990)	Used in Taiwan Province of China (Wade 1990)	Used in Singapore (Mani 2000) and Malaysia (Mani 2000)
Industry (sector) specific technology support institutions	Assumption is that sectors differ quite substantially from each other. Some have mature technologies (foundries and textiles), others have more science-based technologies (bio-technology, advanced materials). Because of this industry specific technology support institutions are needed to cater to the specific demands of specific industries	Used in Malaysia (Felker 1999) and Thailand (Arnold *et al*. 2000)	Used in Taiwan Province of China (Wade 1990)	Used in Singapore (Mani 2000) and Malaysia (Mani 2000)
Joint university–private industry linkage programs	Assumption is that these can be used to overcome market failures in the development of new products and processes	Used in Malaysia (Mani 2000) and Thailand (Arnold *et al.* 2000)	Used in Taiwan Province of China (Wade, 1990)	Used in Singapore (Mani 2000) and Malaysia (Mani 2000)
National standards and metrology agencies	For manufacturing firms to successfully compete in local and global markets they must be able to meet national and international standards, such as ISO 9000 quality standards. Objective of national standards and testing agencies is to help local firms meet international standards required for exporting	Used in Malaysia (Mani 2000), Republic of Korea (Rock 1992), and Thailand (Arnold *et al*. 2000)	Used in Taiwan Province of China (Wade 1990)	Used in Singapore (Mani 2000) and Malaysia (Mani 2000)

(*Continued*)

TABLE 2.3. Technology policies and institutions used for different pathways to technological upgrading in East Asia (*Continued*)

Policy/institution	Objective	Pathway to technological upgrading		
Technology supply–enhancing instutions/incentive policies	Rationale for policy and/or institution	Building large-scale domestic conglomerates	Building a national technology system linked to local SMEs and the global economy	Linking local SMEs to the global value chains of multinational corporations
Productivity centers and SME technology support institutions	SMEs assumed to have substantial difficulty assimilating new technologies. These support institutions have been designed to help SMEs overcome these problems	Used in the Republic of Korea after democratization and less successfully in Indonesia (Berry and Levy 1994) and Thailand (Rock 1984)	Used in Taiwan Province of China (Wade 1990)	Used in Singapore (Mani 2000) and Malaysia (Mani 2000)
Special purpose funds (subsidized credit, tax incentives or grants) for special purposes such as saving water (Singapore), saving labor (Taiwan Province of China), or purchasing locally made capital equipment (Republic of Korea and Taiwan Province of China)	These special purpose funds are used to increase incentives to meet these very particular objectives	Used in Republic of Korea (Rhee *et al.* 1984) and to a lesser degree in Malaysia (Mani 2000) and Thailand (Arnold *et al.* 2000)	Used extensively in Taiwan Province of China (Wade 1990)	Used in Singapore (Mani 2000)
Tax incentives for R&D expenditures of private sector firms. Often focused on promoted industries and applied to the R&D expenditures of firms	By increasing the incentives for firm-level R&D in promoted industries, tax incentives can stimulate the demand for R&D by making it more attractive	Used in the Republic of Korea (Kim 1997 and Rhee *et al.* 1984) and to a lesser degree in Malaysia (Mani 2000) and Thailand (Arnold *et al.* 2000)	Used extensively in Taiwan Province of China (Wade 2000)	Used in Singapore (Mani 2000)
Grants for R&D expenditures often focused on promoted industries. Often applied to the R&D expenditures of foreign as well as local firms	By increasing the incentives for firm-level R&D in promoted industries, tax incentives can stimulate the demand for R&D by making it more attractive	Used in the Republic of Korea (Kim 1993, 1997) and to a lesser degree in Malaysia (Mani 2000) and Thailand (Arnold *et al.* 2000)	Used extensively in Taiwan Province of China (Wade 1990)	Used in Singapore (Mani 2000)

technology rather than needed services and information, such as standards and information, to the private sector (ibid. 103–11).

Taken together, the underlying enabling conditions (such as macroeconomic stability) identified above, the demand-increasing market-building export-oriented 'technology' policies that increased firms' demand for other firms' technology and for skilled people, and supply enhancement policies/institutions identified in Table 2.3 in the East Asian newly industrializing economies were part and parcel of integrated national visions for industrial development. Where integrated visions of national industrial development were lacking, demand-increasing technology policies and supply-enhancing technology support institutions have been less successful (Teubal 2002: 17). In some places (for the Republic of Korea see Jones and Sakong 1980) this vision and package of policies and institutions focused on creating large export-oriented indigenous conglomerates or medium-sized export-oriented domestic firms (for Taiwan Province of China see Wade 1990) that could compete with MNCs based in the OECD (Organization for Economic Co-operation and Development). In other places (for Singapore see Huff 1999; for Malaysia see Rasiah 2001; Churchill 1995), vision/policies/institutions initially focused on attracting export-oriented MNCs from the OECD. Subsequently, focus shifted to creating and upgrading indigenous SMEs and/or creating larger indigenous firms that could either participate in the global value chains of OECD multinationals or compete with those MNCs in the global arena (Mani 2000). In yet other instances (for Indonesia see Rock 1999; for Thailand see Rock 1995; for Malaysia see Searle 1999) the initial focus of national industrial visions and of technology development policies and institutions was on the creation of large-scale indigenous conglomerates that served local markets. Subsequently, visions, incentives, and institutions shifted to include exports (Rock 1995; 1999).

Several other aspects of successful demand-increasing and supply-enhancing technology policies and institutions deserve mention. Quite often specific elements in the package of demand-increasing incentive policies focused on stimulating the demand for technology in particular firms or industrial sectors (Rhee *et al.* 1984; Amsden 1989; Kim 1997; Wade 1990; Evans 1995). In addition, sometimes these policies discriminated against foreign firms by excluding them from certain sectors (Mardon 1990), denying them access to privileges offered domestic firms (Rock 1995, 1999), and/or imposing performance requirements on foreign firms that were different from those imposed on domestic firms (Doner 1991). Limited available evidence suggests that these 'selective' policies were at least partially responsible for the ability of local firms to successfully technologically upgrade (Amsden 1989; Kim 1997; Wade 1990). Unfortunately, virtually all of the policies identified in Table 2.3 that focus on particular firms or sectors deny foreign firms access to privileges offered domestic firms, and/or that impose performance require-

ments on firms are no longer permitted by the WTO. This has led some (UNDP 2003; Wade 2003; Rodrik 2002) to argue that the WTO favours integration of the global economy over development. There is growing fear that, by itself, this shift will make it more difficult for other developing countries to successfully engage in manufacturing technological catch-up (Wade 2003; Chang 2002).

To complicate matters, there are relatively few rigorous quantitative assessments of the success/failure of particular policy/institutional elements in the policy/institutional database identified in Table 2.3.[8] Thus, for example, while it is generally agreed (Rhee *et al.* 1984 and Westphal 1978 for the Republic of Korea; Wade 1990 for Taiwan Province of China; and Huff 1999 for Singapore) that the package of incentive policies/support institutions identified in Table 2.3 played some role in the technological upgrading successes of firms in the East Asian newly industrializing economies, there is less agreement about the impact of particular policies and institutions (World Bank 1993). Moreover, there is ample evidence that what works in one country may not work well or at all in another. This means that it is particularly difficult to identify a standard package of demand-increasing incentive policies and/or supply-enhancing support institutions. Finally, it is increasingly recognized that the conditions facing today's developing countries, particularly the entry of China and India into large-scale exports of manufactures and the increasing reliance of the OECD's multinationals on geographically disbursed global production networks, are substantially different than those faced by the first and second tier manufacturing exporters in the developing world (Felker 2003). What this all means is that it is no longer clear whether the package of policies and institutions identified in Table 2.3, along with the package of policies identified as providing the underlying conditions for manufacturing export success, are necessary and sufficient for successful technological upgrading in the twenty-first century.

Despite this, several clear lessons emerge from the successful experiences of technological upgrading in East Asia. To begin with, there is virtually no evidence to suggest that technological development policies and institutions as broadly defined in Table 2.3 can succeed in the absence of credible commitments by governments to adopt and sustain policies that establish the basic underlying conditions, such as political stability and macroeconomic stability, for firm-level investments in long-term and uncertain technological learning activities. But even if those conditions are established and sustained over time, by themselves they are insufficient to promote high-speed technological learning. Governments also need to craft a wide range of

[8] This is particularly so for technology support institutions (communication with Larry Westphal), but it is equally the case for many of the demand-increasing incentive policies.

demand-increasing incentives or a demand-increasing incentive system that rewards firms for engaging in technological learning (Teubal 2002). This system must recognize that competition from the global economy can stimulate the demand for technological learning (Westphal 2001) particularly if technological upgrading policies accept that most technological learning occurs within firms and is largely the consequence of technology and people flows between firms (Arnold *et al.* 2000). This system must also be consistent with the basic political economy and/or institutional structure of particular countries (Teubal 2002). Finally, it is crucial for governments to recognize that public technology support institutions will most likely succeed when there is sufficient private sector demand for the services they offer (Arnold *et al.* 2000).

2.7 Summing Up

This chapter has reviewed what is known about the determinants of successful technological upgrading and industrial capability building among firms in developing economies in East Asia. We have considered this question in some detail because improving the environmental performance of industrial firms in developing economies is fundamentally an issue of industrial upgrading and capability building—of developing, deploying, and using product and process technologies that are ever less energy, materials, and pollution intensive. We began by recognizing that industrial capability building is predominantly a process pursued by firms, and by firms as part of complex industrial networks. However much technological capability building is an activity of firms, however, we showed that the success of firms in developing economies in engaging in rapid technological learning depends on the presence of a variety of enabling institutional conditions. We also showed that the governments of the East Asian NIEs used a variety of specific policy interventions to support and accelerate technological learning by firms. Crucially, we argued that these policy interventions succeeded to the extent to which they led to increasing demands by firms for technology upgrading and capacity building, and to the extent that they leveraged international markets and production networks that allowed firms to access and accrue technological know-how. Stated another way, the policy interventions pursued by the East Asian NIEs were in the end successful not as autonomous supply-driven policy initiatives, but as initiatives that stimulated a demand for know-how on the part of firms. The significance of this point only increased during the 1990s and beyond as firms in many of the developing economies of East Asia developed ever stronger internal capabilities for engaging in technological upgrading, and as traditional supply-driven

incentives were constrained by the WTO and other multilateral agreements. In the next chapter we turn to the question of how this understanding of industrial and technological capabilities building in the East Asian NIEs can be used to address the issue of improving the environmental performance of industry in the region.

Appendix 2A. Countries Used in UNIDO Competitive Industrial Performance (CIP) index Reduced Form Regressions in Chapters 2 and 9: Data are for 2000

Albania
Algeria
Argentina
Australia
Austria
Bahrain
Bangladesh
Belgium
Bolivia
Brazil
Cameroon
Canada
Central African Republic
Chile
China
Columbia
Costa Rica
Czech Republic
Denmark
Ecuador
Egypt
El Salvador
Ethiopia
Finland
France
Germany
Ghana
Greece
Guatemala
Honduras
Hong Kong, China
Hungary
India
Indonesia
Ireland
Israel
Italy
Jamaica
Japan
Jordan
Kenya
Korea
Madagascar
Malaysia
Malawi
Mauritius
Mexico
Morocco
Mozambique
Nepal
Netherlands
New Zealand
Nicaragua
Nigeria
Norway
Oman
Pakistan
Panama
Paraguay
Peru
Philippines
Poland
Portugal
Romania
Russian Federation
Saudi Arabia
Senegal
Singapore
Slovenia
South Africa
Spain
Sri Lanka
Sweden
Switzerland
Taiwan Province of China
Tanzania
Thailand
Tunisia
Turkey
Uganda
United Kingdom
United States
Uruguay
Venezuela
Yemen
Zambia

3

Policy Integration: From Technology Upgrading to Industrial Environmental Improvement

3.1 Introduction

How might governments in East Asia take advantage of their technological capabilities building policies to lower the environmental burden of high speed industrial growth within the region? Our answer to this question draws heavily on the increasing dissatisfaction within the OECD economies in the traditional way, through command and control environmental regulatory agencies, in which governments in the OECD have pursued improvements in the environmental performance of industry (Davies and Mazurek 1998; NAPA 1995). As some (Hausker 1999) have argued, command and control regulatory approaches fail to capitalize fully on the innovative capabilities of firms and industries and as a result generate costs of abatement that are unnecessarily high. Because of this, others (Chertow and Esty 1997; Gunningham and Grabowsky 1998) have urged greater flexibility and innovation in how environmental goals are met. Various alternatives have been proposed, including greater use of information-based policy tools, devolution of policy implementation to regions and localities, and increased co-operation between government and industry in seeking cost-effective solutions to environmental concerns. Critics of these proposed reforms suggest that ceding discretionary decision-making authority to firms and industries amounts to a weakening of regulatory enforcement that will undermine future gains in environmental performance.

Our purpose in this chapter is to build on the calls for environmental regulatory reform by demonstrating that there are approaches to improving the environmental performance of industry that are emerging in East Asia that take greater advantage of the capabilities building activities of firms in developing economies without sacrificing the ability of regulators to hold these firms to tough performance standards. We do so by examining the contribution of a broad array of government institutions in such reform initiatives in the rapidly industrializing economies of East Asia. Within the United States, environmental regulatory reform initiatives are focused

primarily upon the environmental regulatory agency, the US Environmental Protection Agency (US EPA). Various European countries have explored different approaches to environmental protection, such as the creation of 'environmental covenants' between government and industry in the Netherlands. In the newly industrializing economies of East Asia, where environmental protection agencies are often weaker and less well resourced, policy makers are reconsidering the potential contribution to environmental improvement of a wider array of government institutions, including agencies of economic and industrial development at the national, regional, and local levels. More generally, the East Asian NIEs have begun to link directly a variety of mainstream economic policies, including those related to investment and trade, to environmental goals.

It is this broader approach to improving the environmental performance of industry, and more generally to improving environmental quality in the large urban areas where much of this industry is located, that we label policy integration. Our research suggests that policy integration in the East Asian NIEs likely began as a series of largely pragmatic responses to addressing concerns around resource availability and declining environmental quality in the region. In Taiwan Province of China, for example, issues of water availability for industry and consumers were a major concern, as was dependence on non-local sources of energy. In Malaysia, Thailand, Hong Kong, China, and elsewhere, concerns were voiced that poor urban environmental quality was threatening the capacity to recruit additional foreign direct investment to the region, and more generally acting as a drag on productivity through poor health of workers (UNESCAP 2001). With somewhat weak free-standing environmental regulatory agencies, many of the East Asian NIEs turned to the stronger institutions of economic development to secure an effective response to these environmental concerns. We believe the response took this form in part because of the emergence within the Asian NIEs of coherent industry-led development policies, and of the existence of competent government bureaucracies that recognized that resource and environmental concerns threatened the success of these development policies. That is to say, it emerged within the context of the developmental state that had supported technological upgrading and industrial capability building over the previous two decades.

What began as a pragmatic institutional response to an environmental challenge, however, has quite rapidly transitioned into an approach to improving the environmental performance of industry that has legitimacy and internal coherence on its own terms. A primary reason for this transition and maturation of policy integration as an approach to environmental improvement lies in the fact that the approach taps into one of the fundamental challenges of traditional environmental regulation. Within an environmental regulatory system it is typically firms themselves that are the primary locus of information, ideas, and managerial capabilities needed to

improve environmental performance. And yet freestanding environmental regulatory organizations typically operate at arm's length from these capabilities, influencing technological development and industrial capability activity only indirectly through environmental standards and requirements. Furthermore, many of the processes that influence industrial environmental performance, such as changes in technologies-in-use and capital turnover, are structured by trade and investment policies that typically lie outside of the direct domain of influence of environmental regulatory agencies. Where ways can be found to harness firm-based capabilities toward environmental improvement, and to link economic policies to environmental mandates, the costs of achieving environmental improvement are reduced and the pace of environmental improvement increases. It is on this basic principle that policy integration has transitioned from being a somewhat ad hoc and contextually contingent response to environmental concerns, to an approach that is now gaining widespread attention among developing countries as a way to promote environmental improvement without placing undue constraints on poverty-reducing economic growth.

As we will describe, policy integration among the East Asian NIEs emerged and matured through a process of trial and error and experimentation rather than as a systematically directed approach. Part of the reason for this lies in a lack of prior experience in how to deal with a fundamental dilemma that policy integration poses for government agencies, namely, how to promote cooperation with firms and involvement of industry in environmental improvement without allowing co-option of these processes by firms and industries. As Stigler (1971) and Laffont and Tirole (1991) have argued, it is precisely to prevent the co-option of public goals for environmental improvement by private interests and to avoid 'regulatory capture' that regulatory systems have over the course of time become more bureaucratic, legalistic, and rule based. The dilemma of such traditional regulatory approaches is that they tend to constrict information flow and the range of options available to mobilize the capabilities of firms in securing environmental improvement. In examining how the East Asian NIEs have begun to address this concern we draw upon Peter Evans's (1995) concept of 'embedded autonomy' to consider the ways in which agencies of industrial development can work with firms and industries while simultaneously remaining autonomous from these firms with respect to setting and enforcing environmental performance standards.

Our particular focus in this chapter is on the role of industrial support agencies in promoting improvements in the environmental performance of industry. Currently within the East Asian NIEs this is the manifestation of policy integration that is the most mature and around which there is now becoming available documentation of the contribution of this institutional innovation to environmental improvement (Asian Development Bank 2001). Given the role of these agencies in promoting technological upgrading and

industrial capability building in the region, it is hardly a surprise that they are also at the forefront of policy integration. First, as demonstrated in Chapter 2, agencies of industrial development in East Asia work closely with firms and industries in efforts to improve technological and managerial capability. Research suggests that strategies that improve the overall economic efficiency of firms, such as upgrading managerial and technological capabilities and providing enhanced access to capital and to leading-edge technology, also yield important environmental benefit (Rock 2002*a*). Second, industrial development agencies have access to a wider range of resources and policy tools that can be brought to bear on improving economic and environmental performance, including policies related to investment approval, market access, facility licensing, resource pricing, and land-use planning. Third, in contrast to the relatively weak position of many freestanding environmental regulatory agencies, industrial development agencies typically are well resourced and have important positions of influence with respect to industrial and development planning within industrializing economies. Stated another way, industrial development agencies are embedded in the economic process—in the fundamentals of investment, technology development, and trade—in ways that nascent environmental agencies typically are not. As the concept of embedded autonomy suggests, however, engagement with private firms needs to be balanced with autonomy from those firms.

In this chapter we focus on four instances of policy integration involving economic development agencies, namely, the role of the Industrial Development Bureau in the Ministry of Economic Affairs in reducing industrial pollution in Taiwan Province of China, the role of the Department of the Environment and the Palm Oil Research Institute of Malaysia in pollution control in the palm oil industry in Malaysia, the role of the Economic Development Board and the Jurong Town Corporation in influencing environmental performance of industry in Singapore, and the use of an innovative public disclosure program in China in which the environmental performance of the major cities in China is annually rated, ranked, and publicly disclosed. These case studies of policy integration are followed by a more formal econometric test of our policy integration hypothesis. Hypothesis testing focuses on an intensities variable—namely the CO_2 intensity of industrial value added in nine Asian economies between 1960 and 1998. To anticipate the conclusions, we find substantial empirical support for our policy integration hypothesis.

Taken together the results of the four cases and the statistical analysis suggest that a form of policy integration that more directly integrates economic and environmental goals within agencies of industrial development may be feasible, but only where there exist a relatively strong environmental regulatory agency and a similarly strong and autonomous government bureaucracy and where there is strong societal commitment to improving the environmental performance of industry. Engagement with industrial development agencies in East Asia created the conditions under which environmental

regulatory agencies could succeed in setting and pursuing environmental performance goals (Angel and Rock 2001). Our case studies of policy integration show that relations among different government agencies, particularly between agencies of industrial development and agencies of environmental regulation, are a critical part of the approach taken to improving environmental performance.

With industrial support agencies becoming increasingly involved in promoting environmental improvement of industry within the framework of policy integration, the institutional conditions under which governments can successfully promote industrial capability building, as discussed in Chapter 2, emerge as a key concern for developing countries seeking to learn from the experience of the East Asian NIEs in balancing goals of environmental improvement and poverty-reducing economic growth. In the concluding part of this chapter we take stock of why policy integration has worked within the region, and the conditions under which the approach might be relevant to a broader array of developing economies.

We begin the analysis, however, by returning to the issue of environmental regulation, and specifically to the role that environmental regulatory agencies have played in promoting the environmental performance improvement of industry within the East Asian NIEs within the framework of policy integration.

3.2 Environmental Regulatory Agencies of the East Asian NIEs[1]

The framework of policy integration might easily be misread as suggesting a shift of responsibility for environmental improvement from environmental regulatory agencies to industrial development agencies within the region. This would misrepresent what has actually occurred among the East Asian NIEs that have successfully driven forward improvements in the environmental performance of industry. In fact we know of no cases within the region where significant environmental performance has occurred in the absence of a credible environmental regulatory agency. Where the industrial development agencies have contributed is by building capability to respond to environmental demands, thus complementing rather than replacing the traditional role of environmental regulatory agencies in setting and enforcing environmental standards. In the process of policy integration, somewhat weak and under-resourced environmental regulatory agencies have been built up into more credible institutions that are a necessary part of environmental performance improvement.

[1] This and the following section of the chapter draw upon material previously published in D. P. Angel and M. T. Rock (2003), 'Engaging Economic Development Agencies in Environmental Protection: The Case for Embedded Autonomy', *Local Environment*, 8/1: 45–59.

Effective agencies of environmental regulation in the region have a number of common characteristics. First these agencies in East Asia have adopted clear performance goals and expectations that were consistently pursued and implemented (Rock 2002*a*). Typically, these goals were rooted in national environmental legislation. Such national legislation authorized the establishment of a cabinet-level environmental agency, such as China's State Environmental Protection Administration, or Singapore's Ministry of Environment, that was charged with setting ambient environmental standards, and that had the capability to link achievement of these ambient standards to emission limits for firms and industries (Rock 2002*a*). Typically, emission limits were based on best available technology not entailing excessive costs. And as will be demonstrated in Chapter 4, regulatory pressure has led firms in several East Asian economies—particularly Indonesia and Korea, but also in China and elsewhere (World Bank 2000)—to invest in pollution abatement.

Clear performance expectations required rigorous and consistent enforcement of emissions and ambient environmental standards. Whatever the level of a country's environmental performance goals, modest or ambitious, when pollution management policies are unevenly and inconsistently applied this translates into unclear and uncertain messages concerning performance expectations, resulting in higher levels of malfeasance and erosion of benefits for leading firms. An important first step to influencing basic industrial decision-making, therefore, is a national environmental regulatory system that provides clear performance expectations that are consistently enforced. Consistent regulatory enforcement was a prerequisite for widespread compliance with environmental standards and for the achievement of environmental performance goals (Rock 2002*a*). Effective enforcement required policies, rules, and resources, and a level of institutional 'reach' that stretched from the national to the regional and the local scale.

These increasingly capable pollution management agencies also adopted appropriate policy tools. In the context of East Asian development, it was imperative that environmental regulatory institutions made use of policy tools that allowed economic actors full flexibility in selecting cost-effective strategies for meeting environmental performance expectations. Typically, this involved some combination of ambient environmental standards and emissions standards, multi-media pollution control, pollution charges, resource pricing that reflected environmental cost, use of other market-based instruments, such as emissions trading, as well as various forms of informal, private law, and community-based regulation, such as public disclosure of environmental performance information (World Bank 2000). In most cases, flexibility was obtained through case-specific decision-making, for example, allowing regulatory personnel some flexibility of response based on their knowledge of local circumstance. This can be most clearly seen in the response of the Department of the Environment in Malaysia to growing technological capabilities in the domestic oil palm

processing industry to significantly reduce emissions from oil palm processing without endangering the growth or exports of the firms in this industry (Vincent *et al.* 2000).

The most effective environmental regulatory agencies also had capacities to learn and adapt to change. East Asia's successful environmental regulatory agencies were pragmatic, opportunistic, had flexibility of response, coordination across scales, the capacity to learn from experience, and to adapt to changing economic and political circumstance (Rock 2002*a*). This was especially important with respect to the selection and implementation of policy tools as clearly seen in the innovative use of community-based and informal systems of regulation in Indonesia, other developing Asian countries (World Bank 2000), and China. They also developed regulatory systems rich in information. Such information richness began with standardized information on environmental performance, the bedrock of regulatory compliance. But information richness extended to a broader set of economic, technological, and social characteristics, including the economic circumstance of firms, the track record of good faith behavior or of malfeasance, and the availability of alternative production processes and technologies that offer environmental improvement at lower cost. Such information richness typically extended beyond the limits of the regulatory agencies themselves; it included information developed by industrial policy agencies on the energy, water, and materials intensities of industrial production by disaggregated industrial sectors (Angel and Rock 2003).

3.3 Policy Integration

Policies and strategies for industrial environmental improvement did not stop with the creation and empowerment of traditional environmental agencies. In a significant number of countries—from Singapore and Malaysia in Southeast Asia and to China and Taiwan Province of China in Northeast Asia—policy makers increasingly turned to policy integration, or the direct integration of policy approaches that build technological capabilities and enhance the environmental performance of industry (Angel and Rock 1997, 2003; Rock 2002*a*). Rather than addressing environmental performance exclusively through the external pressure of freestanding environmental agencies, policy integration helped internalize environmental considerations within the basic economic decision-making of firms and industries, and within the policies of the industrial development agencies that bore primary responsibility for promoting industrial growth.

Integration of environmental considerations into the institutions of industrial policy followed somewhat different pathways but they all depended on three dimensions of policy integration: forging relations between environmental regulatory agencies, the powerful state institutions of industrial

development, and private sector firms; reducing abatement costs; and adoption of an information-driven approach to promote demand for environmental improvement. Close relations with industrial development agencies proved critical to gaining support for environmental improvement in government and business and in identifying cost-effective abatement options as well as opportunities for lowering the energy, water, and material intensities of production. How this has been done varied quite significantly from economy to economy.

Singapore's (Rock 2002*a*) pathway to policy integration (Angel and Rock 2003) linked the promotional decisions of its investment promotion agency, the Economic Development Board (EDB), and the infrastructure and plant site decisions of its premier infrastructure agency, the Jurong Town Corporation, to a requirement that firms receiving support from both of these agencies meet the environmental requirements of its environmental agency, the Ministry of the Environment (ENV). This gave the ENV an important seat at Singapore's industrial policy table. Because of strong opposition from its industrial policy agency, the Industrial Development Bureau (IDB) in the Ministry of Economic Affairs, the government of Taiwan Province of China (Angel and Rock 2003; Rock 2002*a*) deliberately bypassed this premier industrial policy agency when it created a strong environmental agency. But by granting the environmental agency legal authorities, technical capabilities, and the administrative discretion to impose tough sanctions on firms that failed to meet emissions standards, the government signaled to this industrial policy agency that it was serious about environmental clean up. This led the industrial policy agency to devise, with the government's consent, its own substantial industrial environmental improvement program. As a consequence, Taiwan Province of China followed a pathway to industrial environmental improvement that integrated environmental considerations—particularly those relating to energy, water, materials, and pollution intensities of firm- and sector-specific production—into its national innovation system. Malaysia's somewhat weaker environmental agency also relied on close relations with firms in the crude palm oil (CPO) industry, a powerful industry association, and a prominent palm oil research institute to clean up CPO wastewater emissions (Angel and Rock 2003). And China's even weaker environmental agency developed a unique public disclosure program that held mayors in the country's largest cities responsible for the environmental performance of those cities. Since mayors were also actively involving in promoting industrial development and growth in China's cities, this public disclosure program forced mayors to balance industrial development objectives with environmental objectives. They did so by practicing a uniquely Chinese version of policy integration.

Singapore's (Rock 2002*a*) decision to elevate its environmental agency to co-equal status with its industrial promotion agency and its premier infrastructure agency reflected a decision to build the economy as a clean and

green first world oasis for multinational corporations in Southeast Asia. As is well known, the country's EDB scoured the world for industries and firms it wanted to attract. It offered promotional privileges—typically tax holidays, accelerated depreciation allowances, and access to space in one of the country's premier industrial estates administered by the Jurong Town Corporation (JTC)—to get firms in particular industries to locate in Singapore (Huff 1999). But before promotional privileges were granted by the EDB and space allocated by the JTC, the Ministry of the Environment (ENV) had to approve each firm's production process and its plan to abate pollution to meet the country's tough emissions standards. Occasionally, the ENV rejected a particular industry as too polluting; more frequently it worked closely with these firms to identify cost-effective treatment technologies. The ENV also worked with the JTC to locate the most polluting industries as far as possible from residential and commercial populations. By doing so, the ENV helped the JTC to shrink the geographic distribution of hazardous activities and to co-locate similar activities with similar waste streams in the same locations. This facilitated several common solutions to pollution problems.

Malaysia's (Angel and Rock 2003) decision to link its environmental agency, the Department of the Environment, with CPO mills, a CPO industry association, and an oil palm research institute, PORIM—the Palm Oil Research Institute of Malaysia—in an effort to reduce the water pollution associated with CPO processing reflected a political reality that CPO mills could not be shut down without undermining the government's most successful rural anti-poverty program. This program, managed by the Federal Land Development Authority (FELDA), developed new small-farmer palm oil farms complete with infrastructure clustered around larger palm oil estates and CPO mills. Following race riots in 1969 and the subsequent announcement of Malaysia's New Economic Policy, which was designed to reduce poverty among rural ethnic Malays, both privately financed and FELDA financed palm oil production schemes and CPO production grew exponentially as Malaysia captured a large share of the world CPO market. But this came at substantial environmental cost, as CPO wastes soon clogged a large number of the country's major rivers. Trapped between the economic success of its small-farmer and poverty-reducing oil palm schemes and growing complaints about CPO wastes from rural ethnic Malays, the government set out on a pragmatic search for cost-effective treatment technologies. Once these technologies were identified by PORIM and evidence accumulated that CPO mills were adopting these treatment technologies without undermining profitability or exports in the industry, the Department of the Environment (DOE) imposed emissions standards and ratcheted them up over time as more cost-effective treatment technologies emerged. The result was an effective de-linking of pollution from the scale of palm oil production and exports.

The government of Taiwan Province of China (Angel and Rock 2003) followed a third pathway to policy integration by developing an industrial environmental program based on ratcheting up the industrial environmental performance of firms and industries, defined in terms of the energy, materials, water, and pollution intensities of industrial value-added, to meet international best practices. Because its premier industrial policy agency, the IDB in the Ministry of Economic Affairs, opposed the environmental clean up, fearing it would undermine the profitability of industry at a time industry was being 'hollowed out' by rising wage rates and an appreciating currency, the government's environmental program initially bypassed the IDB. Once the environmental agency began imposing sanctions on polluters, the IDB realized that it needed to develop its own environmental strategy. Thus, a pollution-prevention, waste-minimization program was developed jointly with the Taiwan Environmental Protection Administration (Rock 2002*a*, 2002*b*). The IDB not only offered promotional privileges to firms for the purchase of pollution control equipment, but also used its promotional privileges to foster the development of an indigenous environmental goods and services industry that it expected to become export-oriented. As has been typical of the IDB's export promotion programs, it set quantitative export targets for this industry and appears to have conditioned access to promotional privileges for meeting those targets. And most surprisingly, the IDB invested into the creation of a state-of-the-art research program on the energy, water, materials, and pollution intensities of Taiwanese industries in the Industrial Technology Research Institute (ITRI), the premier science and technology institute in Taiwan Province of China.

The State Environmental Protection Administration of the People's Republic of China followed a fourth pathway to policy integration. Since 1989, China's State Environmental Protection Administration (SEPA) has been working closely with city-level environmental protection bureaus (EPBs) to annually rate, rank, and disclose the environmental performance of the country's major cities (Rock 2002*a*). SEPA's Urban Environmental Quantitative Examination System (UEQES) is one of eight environmental policy instruments used by SEPA to reduce pollution. Assessment of a city's environmental performance is based on a city's composite score on some 20 environmental indicators. Cities are ranked on the basis of their composite scores and SEPA publishes ranks and scores in its annual environmental yearbook. Some provinces and cities have followed this practice by publicizing scores and rankings in newspapers and on radio and television.

Prior to the initiation of this public disclosure program, environmental officials in these cities stated they had a difficult time getting the attention of either mayors or of those in powerful economic and industrial development agencies. Subsequent to the disclosure of cities' scores and ranks, this began to change. Over time, this public disclosure program captured the attention of mayors, who wanted to know why their city scored and ranked lower

than other cities. They also wanted to know what was in the index, how it worked, what could be done to increase a city's score and rank, and the costs involved.

This interest in the program by mayors provided city-level environmental protection bureaus (EPBs) with their first real opportunity to cooperate with more powerful economic and industrial development agencies over environmental issues. Cooperation revolved around the annual plan and five-year plans for improving the environment within cities. Production and implementation of these plans are under the authority of a city's environmental protection commission (EPC). Normally, the EPC is chaired by either the mayor or vice-mayor. Other members of the EPC include the city's economic commission, its industrial bureaus, its finance bureau, and several others. Implementation of a city's response to the public disclosure program is led by the EPC. The process is initiated by the mayor, who requests each line agency and sector/district within a city to put together a report that evaluates their performance relative to the previous year's environmental targets and proposes environmental targets for the current year. The EPB analyses this information, consults with appropriate line agencies, sectors, and districts, and sets a projected overall target score on the public disclosure index in a background report prepared annually by the EPB for submission to the EPC. This background report describes what the city did to improve its score of the previous year, identifies the major environmental problems in the city, proposes targets by indicator for the current year, and assigns responsibility for meeting those targets to the appropriate line agencies.

Following receipt of the background report, the EPC holds meetings on the program to review past progress, examine current environmental problems, agree on the current year's target score, and assigns responsibility for meeting targets to specific line agencies, sectors, and districts. This meeting culminates in the signing of environmental target responsibility system contracts between each sector of government, including politically powerful industrial bureaus, and the mayor. These serve as the basis of the mayor's environmental target responsibility contract with the provincial governor. Approximately two meetings are held annually between senior representatives of the EPB and each line agency in city-governments to evaluate their performance relative to targets. The results of these meetings are rolled up into mid-year and end-of-year EPC reviews of progress by line agency, sector, and district. The EPB is responsible for the preparation of background reports for these reviews.

Evidence gathered in several cities suggests that this whole process is making an environmental difference. In Tianjin, the local EPB used the process to reduce total suspended particulate levels (TSP levels) in the city. In the 1980s, TSP levels averaged about 500 mg/m^3 in the city, although recently they have fallen to about 300 mg/m^3. The decline in TSP levels can be traced to a number of changes including the closing of small-scale industrial

boilers and the mandating of pollution abatement equipment on large industrial boilers.

Based in large part on the success of the national UEQES program, China introduced a more comprehensive initiative in policy integration known as the model city program. In order to be accepted into the model city program, cities had to be ranked in the top quartile of cities nationally in the UEQES program for three consecutive years. In addition, cities had to meet a series of specific performance benchmarks in four areas: (i) social and economic development; (ii) environmental quality; (iii) investment in environmental improvement; (iv) environmental management. For each of these four areas, a series of performance benchmarks was established. For example, in the area of investment in environmental improvements, cities are required to spend at least 1.5% of GDP on environmental investments, such as construction of wastewater treatment plants. In the area of environmental quality, model cities were required to maintain ambient air quality such that on at least 80% of days each year the air pollution index was lower than 100 (this is China's level II state standard on a national air pollution index).

As suggested by the policy integration framework, at the core of the model city program were the mobilization and coordination of all government departments toward achieving prescribed performance benchmarks in both economic and environmental performance. Typically the mayor of a city establishes a coordinating cabinet with representation from all government departments and agencies. These departments and agencies are then tasked with developing and implementing plans to meet the model city performance targets.

In order to explore how this approach to policy integration within urban areas works, we conducted a series of interviews with government officials in the city of Nanjing in Jiangsu province. At the time the interviews were conducted in 2001–2, Nanjing was in the midst of a multi-year effort to achieve model city status by the end of 2003. Nanjing was motivated to achieve model city status on a 'fast track' because it was scheduled to host the Chinese national sports games in 2005 and wanted to take this opportunity to spotlight its accomplishments. But the more fundamental driver for seeking model city status was the strong belief that improvements in environmental quality were required if Nanjing was to continue to attract high levels of foreign direct investment. In the case of Nanjing, the environmental protection bureau (EPB) was asked to take the lead in achieving model city status. The director of the Nanjing EPB was required by the mayor to sign a contract that all of the performance requirements for model city status would be achieved within a three-year period.

Improving ambient air quality was one of the major priorities of the model city plan prepared by the Nanjing EPB. Overall the EPB was asked to identify steps that would result in a net reduction of air pollution emissions of 10% within five years. Given the rate of growth of the Nanjing urban

economy,[2] this was a very aggressive goal. Table 3.1 shows three measures of urban air quality in Nanjing for the period 1984–2000 (total suspended particulates, sulphur dioxide (SO_2), and nitrous oxide (NO_x) emissions). As can be seen, environmental quality improves and particular gains are achieved in the 1998–2000 period in reducing TSP and SO_2 emissions. To achieve these improvements, Nanjing has focused on three areas, namely, replacement of coal-fired boilers by oil, gas, and electric power supply, management of dust from construction sites,[3] and inspection programs for passenger vehicles.

Nanjing is making good progress on most of the model city performance goals, but still has a considerable way to go to improve air quality and wastewater treatment. For example, the model city program requires that 60% of waste water receive a minimum of secondary treatment. As of the end of 2000 the city was providing secondary treatment to just 30% of residential waste water. Plans are in place to complete four new major wastewater plants that would provide capacity for up to 90% of the city's waste water.

TABLE 3.1. Air quality in Nanjing, China

Year	TSP	SO_2	NO_x
1984	0.653	0.083	0.06
1985	0.405	0.078	0.045
1986	0.548	0.073	0.059
1987	0.418	0.09	0.059
1988	0.426	0.089	0.054
1989	0.359	NA	NA
1990	0.292	0.078	0.051
1991	0.299	0.055	0.057
1992	0.241	0.073	0.05
1993	0.281	0.049	0.05
1994	0.299	0.055	0.048
1995	0.317	0.062	0.049
1996	0.299	0.055	0.05
1997	0.281	0.055	0.051
1998	0.253	0.048	0.053
1999	0.202	0.034	0.051
2000	0.187	0.029	0.048

Note: TSP refers to total suspended particulates; SO_2 refers to sulphur dioxide; and NO_x refers to nitrous oxide.

[2] Nanjing is a major location for foreign direct investment.

[3] At the time of our interviews there were approximately 2,000 large active construction sites in the city, reflecting the rapid growth of urban industry in the city.

What these case study examples indicate, in sum, is that the East Asian NIEs and China have had considerable success in mobilizing the resources of economic development agencies to the task of improving the environmental performance of industry within the region. We now go beyond these case examples to a statistical analysis of the links between policy integration and one critical environmental variable, namely, CO_2 emissions.

3.4 Econometric Tests of the Efficacy of Policy Integration in Asia

Is there broader statistical support for this case evidence linking policy integration to improved environmental performance of firms and countries in Asia? We answer this question by demonstrating that for the pollution intensity of one critical pollutant—industrial CO_2 emissions per constant dollar of industrial value added—stronger institutions of industrial policy, openness to foreign direct investment, more credible environmental regulatory policies, and higher prices for resources (energy) help lower the intensity of industrial CO_2 emissions. That is, panel regressions on the CO_2 intensity of industrial value added, in a group of Asian countries, show that intensity falls with stronger institutions of industrial policy, openness to foreign investment, more credible regulatory policies, and higher energy prices. While this win–win[4] policy integration opportunity may not be sufficient to turn around Asia's deteriorating environment or forestall global warming, given the need to increase average incomes in Asia, these opportunities should not be overlooked, even if reaping them requires a degree of policy integration that has been difficult to achieve elsewhere.

Our policy integration empirical testing procedure follows the approach we used in Chapter 2 to test hypotheses on the role of institutions and openness on the industrial competitiveness of countries. Thus to begin with, we estimate the following panel regression:

$$CO_2IND_{it} = \mathrm{a}_0 + \mathrm{a}_1\, INT_{it} + \mathrm{a}_2\, INST_{it} + TIME + e_{it}$$

where CO_2IND_{it} is the carbon dioxide intensity of value added of industrial production in country i in time period t, INT_{it} is a measure of integration (or openness) of country i in time period t, $INST_{it}$ is a measure of institutions in country i in time period t, $TIME$ is time, or year, a variable to capture the influence of other variables on CO_2IND, and e_{it} is the error term in country i in time period t. Integration is measured by a country's openness to trade (exports plus imports divided by GDP or (XMY) and its openness to foreign direct investment (foreign direct investment as a share of GDP or $FDIY$). We adopt two distinct measures of institutions. In the first, institutions are

[4] By win–win we mean that the net benefits of this policy package are likely to be positive.

measured by the variable $WS_{it}*D_{it}$ where, as described in Chapter 2, WS_{it} is an estimated value of the Weberian Scale (WS) score for country i in period t as measured by Evans and Rauch (1999). As Evans and Rauch (1999) argue, WS_{it} measures the capability of a country's government bureaucracy to design and implement economic and industrial development policies. Because Evans and Rauch (1999) do not provide time series estimates of WS_{it}, we take advantage of the relationship between WS as reported in Evans and Rauch (1999) and bureaucratic quality (BQ) as reported by Knack and Keefer (1995) to develop time series estimates for each of our nine Asian economies. Since Knack and Keefer (1995) provide time series estimates of BQ_{it}, we obtained time series estimates for WS_{it} by regressing WS_{it} on BQ_{it} and using the resulting regression equation to estimate WS_{it}. We made one adjustment to our estimated values for WS_{it}. In instances where our estimate of WS_{it} diverges significantly from WS as measured by Evans and Rauch for 1995 (1999), we adjust WS_{it} by adding or subtracting a constant to WS_{it} so that WS_{it} in 1995 matches the value of WS for 1995 as reported in Evans and Rauch (1999). We then follow the practice outlined in Chapter 2 by multiplying WS_{it} by D_{it} where $D_{it} = 1$ for country i in period t if the country is pursuing explicit industrial policies during t and $D_{it} = 0$ otherwise. $WS_{it}*D_{it}$ can be interpreted as a measure of the degree to which government institutions, WS_{it}, have the necessary bureaucratic capacity to successfully design and implement explicit industrial policies (D_{it}).

Because our case evidence suggests that policy integration in several East Asian economies takes the form of linking environmental regulatory agencies to the institutions of industrial policy, we created a second measure of institutions by multiplying $WS_{it}*D_{it}$ by REG_{it}, the stringency of environmental regulations in country i in time t. This new variable, $WS_{it}*D_{it}*REG_{it}$, can be interpreted as measuring the degree to which governments in our nine Asian economies have structured relationships between their credible environmental regulatory agencies, REG_{it}, and their institutions of industrial policy, $WS_{it}*D_{it}$, so as to take advantage of the embedded autonomy extant between the institutions of industrial policy and private sector firms in our sample of Asian economies. We supplemented these base panel regressions with several others to take account of the impact of energy prices, the real price of a liter of gasoline in US dollars (*RGASP*), regulatory stringency (*REG*) and industrial structure as measured by the share of heavy (and energy-intensive) industry in industrial value added (*HVYIND*) on the CO_2 intensity of industrial value added. In these latter equations policy integration is defined as an interlinked set of institutions and policies that include the strength and capability of institutions of industrial policy (*WS*D*), the stringency of environmental regulations (*REG*), the linking of environmental regulatory institutions with the institutions of industrial policy (*WS*D*REG*), market pricing for energy (*RGASP*), and openness to foreign trade (*XMY*) and foreign investment (*FDIY*). Given the crude nature of the

data and the limited theoretical work linking industrial CO_2 emissions per constant dollar of industrial value added to our policy integration variables, following standard practice, hypothesis tests were limited to an estimation of a reduced-form policy integration model. The sample is a panel or pooled (cross-country and over time) data set of nine Asian countries over 21 years.

Data for industrial CO_2 emissions, industrial value added, foreign direct investment as a share of GDP, *FDIY*, and for openness to trade (*XMY*) were taken from World Bank (2000). Data on *RGASP* are from the Asian Development Bank (2000) and the World Bank (2004). Data for *HVYIND* were taken from UNIDO (1999) and include the sum of the shares of industrial chemicals, petroleum products, and iron and steel products in industrial value added. *REG* is a subjective measure of the stringency of environmental regulations. It is based on a review of the relevant literature on this topic for each country and interviews of knowledgeable individuals in each country. Some countries, such as India, the Philippines, Sri Lanka, and Thailand, always had less than stringent environmental regulations throughout the sample range of 1960 to 1998 (that is, $REG = 0$). Others imposed stricter environmental regulations, with Singapore (from 1970) leading the way followed by Malaysia (from 1973), the Republic of Korea (from 1986), and Indonesia (from 1995).

The initial estimation of our reduced-form panel regressions included both a fixed effects and a random effects model. The fixed effects model treats differences between each country as parametric shifts of the regression function (Greene 2000: 567). If country-specific constant terms are more appropriately considered as randomly distributed across each country, as they might well be if the sample is a subset of a larger one, the random effects model is more appropriate. Because the sample is a subset of Asian countries, a random effects model appears more appropriate. But the random effects model imposes an assumption on the data that the country-specific effects are not correlated with the other regressors in the model (Talukdar and Meisner 2001: 836). This assumption is tested with a Hausman test (Hausman 1978). Based on the value of the test statistic, a χ^2 statistic with seven degrees of freedom, the test fails to reject the hypothesis that country-specific effects are not correlated with the other regressors. The test thus supports the use of the random effects model as is reported in Table 3.2.

One other factor was considered while estimating reduced-form panel regressions on the industrial CO_2 intensity of industrial value added. In a recent paper, Talukdar and Meisner (2001) asked whether the private sector helps or hurts the environment. They tested this hypothesis by including the share of private sector investment in GDP (*PIGDP*) as an independent variable in a reduced-form regression on per capita industrial CO_2 emissions in a sample of developing countries. Their results suggest that the private sector helps the environment. Because of this finding, this variable is included as an additional regressor.

TABLE 3.2. Panel regressions base model (random effects model) of effects of openness and institutions on industrial CO_2 emissions per constant dollar of industrial value added

Explanatory variables	Equations (1)	(2)	(3)	(4)
Constant	12.03	15.03	8.64	8.36
*WS*D*	−0.85	−1.67		
	(−3.94)***	(−6.46)***		
*WS*D*REG*			−0.086	−0.12
			(−3.23)***	(−4.39)***
XMY	0.005	0.006	0.002	−0.001
	(1.61)	(1.63)	(0.59)	(−0.50)
FDIY	−0.14	−0.16	−0.14	−0.16
	(−2.69)***	(−2.89)***	(−2.61)***	(−2.73)***
PIGDP		0.04		0.02
		(2.25)**		(0.119)
TIME	−0.005	0.03	−0.01	0.01
	(−0.56)	(2.11)**	(−2.02)**	(0.84)
Adjusted R^2	0.97	0.98	0.97	0.98
Number of cross sections	9	9	9	9
Time series length	21	21	21	21

Notes: *t* ratios are in parentheses. ***, **, and * indicate significance at 99, 95, and 90% levels, respectively.

Except for Singapore, where these data are from Huff (1999), data for PIGDP are from Bouton and Sumlinski (1995 and 1999).

Results for all base panel regressions appear in Table 3.2. What do they show? To begin with, both of the institutions variables (*WS*D* and *WS*D*REG*) are statistically significant at the 0.01 level in all four equations with the expected sign (stronger institutions lower the CO_2 intensity of industrial value added). This provides powerful evidence of the impact of the institutions of industrial policy (*WS*D*) on industrial environmental outcomes and of the value of integrating those institutions with credible regulatory agencies (*WS*D*REG*) to take advantage of the embedded autonomy of the latter.

On the other hand, our private sector investment variable (*PIGDP*) is statistically significant in one of our equations, but it has the wrong sign—the larger the share of private sector investment in GDP the larger is the CO_2 intensity of industrial value added—and it has the wrong sign in the other equation in which it appears, even though it is statistically insignificant. Given the finding by Talkudar and Meisner (2001), this result seems puzzling. But it just may be that the efficiency impact of private sector investment on

per capita industrial CO_2 emissions disappears once account is taken of the impacts of the stringency of environmental regulations and higher energy prices on those emissions. In other words, private sectors respond to the structure of incentives within an economy. When those incentives encourage savings in energy (as stringent environmental regulations and higher energy prices should do), the private sector responds by doing so. When incentives do not encourage firms to save energy (as when regulations are lax and energy prices are low), the private sector saves less energy and emits more CO_2. There are two distinct reasons to suspect that this line of reasoning makes good sense. First, Talkudar and Meisner (2001: 832) state that energy prices and regulatory stringency are missing from their analysis. Second, strong empirical support for this interpretation can be found in all four of our expanded panel regression equations shown in Table 3.3. There *REG*, the regulatory stringency variable, is always significant (either at the 0.05 or 0.10 level) and it always has the expected sign (negative). *RGASP*, the real price of

TABLE 3.3. Panel regressions expanded model (random effects model) of effects of openness and institutions on industrial CO_2 emissions per constant dollar of industrial value added

Explanatory variables	Equations			
	(1)	(2)	(3)	(4)
Constant	14.11	13.21	9.41	8.53
*WS*D*	−1.07	−1.06		
	(−3.73)***	(−3.78)***		
*WS*D*REG*			−0.13	−0.14
			(−4.59)***	(−4.69)***
REG	−1.02	−1.12		
	(−3.03)***	(−3.22)***		
FDIY	−0.055	−0.09	−0.08	−0.12
	(−1.38)	(−2.02)**	(−2.03)**	(−2.66)***
RGASP	−0.67	−0.42	−1.07	−0.75
	(−2.02)**	(−1.15)	(−3.02)***	(−1.92)*
HVYIND	3.55	3.08	2.52	2.21
	(2.43)**	(1.92)*	(1.67)*	(2.66)***
PIGDP		0.03		0.02
		(1.68)*		(1.00)
TIME	0.006	0.01	−0.03	−0.01
	(0.41)	(0.76)	(−2.51)**	(−0.71)
Adjusted R^2	0.98	0.98	0.98	0.98
Number of cross sections	9	9	9	9
Time series length	21	21	21	21

Notes: *t* ratios are in parentheses. ***, **, and * indicate significance at 99, 95, and 90% levels, respectively.

energy, is significant in three of the four regressions, either at the 0.01 or 0.05 level, and it too always has the expected sign (negative).

What about the openness variables—*FDIY* and *XMY*—are they statistically significant with the expected signs? The share of foreign direct investment in GDP is always statistically significant at the 0.01 level with the expected sign (negative), while the trades share in GDP (*XMY*) is never statistically significant and it has the wrong sign in three of the four base panel regressions in Table 3.2. These results should not be particularly surprising. As several industry-specific studies demonstrate, foreign investors often bring new and cleaner technologies with them when they invest in developing economies and it is next to impossible to prevent the leakage of these newer and cleaner technologies to other firms in the economy. While openness to trade might have similar effects, apparently this is not guaranteed, at least in our sample. Lack of leakages through openness to trade may simply reflect the fact that openness to trade does not necessarily ensure openness to technology. This can happen when countries get stuck in low wage, low skilled, and low technology export-oriented industries.

Table 3.3 reports results for our expanded panel regression model. Because openness to trade (*XMY*) was never statistically significant in our base model (Table 3.2), that variable is omitted from the panel regressions in Table 3.3. This saves degrees of freedom and permits several robustness tests. Results are entirely consistent with the base panel regressions reported in Table 3.2. Both of our institutions variables (*WS***D* and *WS***D***REG*) are always statistically significant at the 0.01 level with the expected sign (negative). This provides additional and powerful evidence of the importance of the institutions of industrial policy (*WS***D*) and of policy integration (*WS***D***REG*) on industrial environmental outcomes. And regulatory stringency (*REG*) matters—those economies with more stringent environmental regulations have significantly lower CO_2 intensities of industrial value added. In addition, openness to foreign direct investment (*FDIY*) always lowers the CO_2 intensity of industrial value added as do higher real prices for gasoline. Finally, as in Table 3.2, private investment as a share of GDP is either statistically insignificant with the expected sign or it has the wrong sign.

Taken together, the panel regressions reported in Tables 3.2 and 3.3 offer powerful support for our policy integration hypotheses. They demonstrate that the institutions of industrial policy (*WS***D*) matter and they provide solid empirical support for the case literature which suggests that governments can drive down the CO_2 intensity of industrial production by integrating credible environmental regulatory agencies with the institutions of industrial policy (*WS***D***REG*). We have also demonstrated that policy matters—particularly regulatory policy (*REG*), openness to foreign direct investment (*FDIY*), and resource price policy (*RGASP*). Because our panel regressions control for the influence of the structure of industry (*HVYIND*)

and time (*TIME*), these results cannot be attributed to the effects of other variables or the composition of industrial output.

3.5 Why does Policy Integration Work?

But why, one might ask, does policy integration work? Case evidence suggests that linking new environmental agencies with more powerful economic development and industrial policy agencies in East Asia helped gain critical support for environmental improvement within government and from business. It fostered trust and confidence between environmental agencies, economic development and industrial policy agencies, and the business community over a shared need to clean up the environment without imposing costs on firms that endangered their profitability, growth, and export potential. The involvement of economic development agencies was a powerful sign to the business community as to the seriousness of the government's commitment to the goal of environmental improvement, as well as to the commitment to finding solutions that did not impose unreasonable costs on firms and industries. Experience with particular policy tools, such as progressively phasing in stricter emissions requirements based on advances in best available technologies that did not involve excessive costs, built confidence that environmental improvement and strengthened economic performance were goals that could be jointly pursued.

Another key benefit obtained by linking environmental protection agencies and development agencies related to lowering abatement costs. Interagency cooperation facilitated access to important information about the costs of abatement and the impact of those costs on profitability and the ability of regulated firms to export. Most importantly, it facilitated joint searches for cost-effective abatement technologies and for ways to reduce pollution intensities and intensities of use of energy, water, and materials. Reducing abatement costs and energy, material, water, and pollution intensities were and are particularly important to firms and governments in East Asia. This is because both were and are convinced that environmental improvement cannot come at the expense of poverty reduction, increasing incomes, diversifying countries, expanding export bases, and upgrading the technical capabilities of indigenous firms in these countries.

Case evidence in East Asia, particularly in Malaysia, Singapore, and Taiwan Province of China, suggests that policy integration contributed in various ways to lower abatement costs. In the early days, Singapore's ENV invested heavily in a worldwide search for the most cost-effective abatement technologies (Angel and Rock 2003; Rock 2002*a*). This empowered the ENV by making it acutely aware of the best available treatment technologies not entailing excessive costs. Because many of the promoted firms in Singapore had little experience with pollution control, the ENV used this information to

develop lists of reputable environmental goods and services providers that it shared with promoted firms. This reduced information barriers for those firms and eased their transition to less polluting technologies. Over time, the ENV got tougher by asking firms seeking promotional privileges if they planned to use cleaner technologies, whether they were willing to substitute materials use to reduce the toxic intensity of production, and how they planned to reduce water use in the face of Singapore's freshwater scarcity. Because the ENV was knowledgeable about international best practices and had intimate relations with promoted firms, it was able to help the firms lower abatement costs and decrease energy, water, materials, and pollution intensities.

As mentioned earlier, the DOE in Malaysia invested heavily in a worldwide search for best available treatment technologies not entailing excessive costs for treating CPO wastes. Finding none, it worked closely with PORIM to develop a treatment technology that worked. Once identified, the DOE used its relationships with PORIM and the CPO industry to track adoption of the new treatment technology. Once it became clear that the treatment technology worked without undermining the profitability and export potential of the CPO industry, the DOE ratcheted up emissions standards, ultimately de-linking CPO production and exports from CPO wastes.

The government in Taiwan Province of China (Angel and Rock 2003; Rock 2002*a*) vested authority for identifying cost-minimizing treatment technologies, for lowering the costs of abatement, and for reducing the energy, water, materials, and pollution intensities of production in the IDB. As in Malaysia and Singapore, the IDB invested in information gathering about the costs of alternative treatment technologies for the firms and industries it promoted. It also invested in a practical joint program with the Taiwan Environmental Protection Administration in pollution prevention and waste minimization. This included co-locating similar SMEs in industrial parks and empowering SMEs in those estates to jointly manage pollution reduction. But the IDB went well beyond these activities. It subsidized the purchase of pollution-control equipment by offering tax reductions and accelerated depreciation allowances and access to subsidized credit for purchase of pollution control equipment. Because the IDB ultimately viewed the development of an indigenous environmental goods and services industry as one of the next steps in its promotional strategy, it subsidized the creation of an indigenous environmental goods and services industry, which it hoped would become export oriented. And it engaged in state-of-the-art research on the energy, water, materials, and pollution intensities of industries in Taiwan Province of China that included benchmarking performance against international best practices.

The case evidence also suggests that each of these regulatory agencies in rapidly industrializing East Asia routinely relied (and relies) heavily on information and disclosure based environmental improvement strategies.

Long-, medium-, and short-term ambient environmental goals for air, water, and land were (and are) set both to drive performance and to communicate to the public the progress made. Similarly, short-, medium-, and long-term emissions standards were (and are) set to drive the performance of firms and to report to the public the degree to which industry was (and is) complying with quantitative standards. In both instances, initial standards have been well below international best practice. This reflects the highly practical step-at-a-time process used to achieve improved environmental outcomes in East Asia. It also enables those in regulatory agencies to learn about the difficulties associated with meeting quantitative environmental goals. While initial standards have been relatively easy to achieve, regulatory agencies also communicated to regulated firms that both ambient and emissions standards would be tightened over time.

Sometimes quantitative standards were set for the intensity of use of water or energy at the firm, industry, and country levels. Because Singapore is extremely short of fresh water and heavily dependent on Malaysia for its freshwater supplies, the government has taken great care to protect freshwater supplies. It not only invested heavily in protecting freshwater supplies, but the EDB provides promotional privileges in the form of accelerated depreciation to firms that invest in water saving or water recycling technologies (Rock 2002*a*). To be eligible for these benefits, firms have to demonstrate that water saving/recycling technologies use less water than more conventional production and abatement technologies. North China, like Singapore, is also short of fresh water. Because of this, the national environmental agency in China has included an intensity of water use indicator (waste water discharged per RMB 10,000 of industrial output) in its public disclosure program that annually rates, ranks, and discloses the environmental performance of the country's major cities (Rock 2002*a*). To date, the industrial policy agencies in Taiwan Province of China have the most extensive experience in the region with intensity of use indicators. The IDB has contracted out state-of-the-art research to the Industrial Technology Research Institute (ITRI) on the energy, water, materials, and pollution intensity of particular industries in Taiwan Province of China (Angel and Rock 2003). In several instances, intensities of resource use, as in wafer fabrication, water use per wafer, and in cement, total suspended particulates per ton of clinker have been benchmarked against international best practice. Following benchmarking, the IDB provided technical assistance through private consulting firms and the ITRI to help Taiwanese firms reach international best practice levels of intensity of use.

As described earlier, the most developed use of information and disclosure to achieve environmental improvement in East Asia occurs in China. There appear to be several reasons why this process worked. To begin with, SEPA and city-level EPBs tethered the UEQES to an environmental target responsibility system used by provincial governors to hold mayors accountable for

the environmental performance of cities. Disclosure of a mayor's performance relative to his contract with the provincial governor alongside disclosure of the ranking of his city by SEPA have been sufficient to get mayors to take steps to meet contract requirements and improve their scores on the UEQES. In addition, both SEPA and city-level EPBs learned how to integrate environmental considerations into economic and industrial policy-making by taking advantage of a bargaining model of policy implementation used by cities to make economic and environmental decisions.

The experiences of China, Malaysia, Singapore, and Taiwan Province of China demonstrate that policy integration is practically possible and that it works. The advantages of developing an environmental policy through policy integration as opposed to stand-alone environmental agencies acting alone are clear. Policy integration fosters critical mutual trust and support for environmental improvement in economic development and industrial policy agencies as well as within the private sector. Without this support, stand-alone environmental agencies have little chance of succeeding. It provides regulatory agencies with inside information on the costs of abatement and those of reducing the energy, water, materials, and pollution intensities of economic activity. This facilitates joint searches for least cost solutions to environmental problems, frees regulatory agencies from having to use the most blunt instruments to gain compliance, and it makes regulatory agencies sensitive to the needs of balancing environmental improvement with the other goals of development. When tethered to the use of information to evaluate and disclose performance, it strengthens public support for environmental improvement.

There are several other reasons governments in each of these countries have been so successful at policy integration. To begin with, each of the policy integration programs described had the commitment and support of key decision-makers and top political leaders. Environmental improvement was a high priority of the prime minister of Singapore (Rock 2002*a*). Unwavering commitment from the prime minister meant that those in industrial policy agencies knew that economic growth could not come at too high a cost to the environment, while those in the regulatory agency knew that environmental improvement could not come at the expense of economic growth. This chastened both to search for least costly solutions to pollution. Promoted firms were willing to abate pollution because they knew it would not come at too high a cost and because Singapore offered many other advantages, such as an excellent infrastructure, low wages and a hard working labor force, and a superb location astride one of the world's busiest shipping lanes.

Something similar was at work in China, Malaysia, and Taiwan Province of China. Faced with an environmental protest movement following democratization and a willingness of opposition parties to blame the ruling party for environmental degradation in Taiwan Province of China, the top leadership of the ruling party committed itself to environmental improvement

(Rock 2002*a*). This unwavering commitment was signaled through the creation of a highly capable and tough regulatory agency that was given broad authority to sanction firms failing to meet emissions standards. This signaled to the IDB that the government was serious about cleaning up pollution forcing the IDB to seek an alliance with the regulatory agency (in pollution prevention) and to launch its own substantial environmental program. By astutely recognizing that it could use its promotional privileges to lower abatement costs and the costs of reducing energy, water, materials, and pollution intensities, the IDB signaled to both the environmental agency and the private sector that it had an important role to play in environmental improvement.

In Malaysia, unwavering commitment by the government to a rural anti-poverty program based on palm oil production and exports meant the environmental agency could not reduce CPO pollution if it undermined the profits and exports of the CPO industry. But because of growing protests over CPO pollution from rural Malays, a vital political constituency for the ruling Malay party, neither the government, nor the private sector, nor the environmental agency could ignore the environmental costs of CPO production. This forced the environmental agency, the CPO industry, and a palm oil research institute to build relationships with each other and engage in a joint search for a least cost solution to pollution. In China, the regulatory agency capitalized on an environmental responsibility system that required mayors to sign environmental performance contracts with provincial governors (Rock 2002*a*). This captured the attention and sustained the commitment of mayors to the agency's city-level environmental rating, ranking, and disclosure program. But as in Malaysia, Singapore, and Taiwan Province of China environmental regulators were also aware that environmental improvement could not come at too high an economic cost to cities and mayors. Because of this, they linked real practical environmental improvements to a consultative process that engaged economic development agencies, industrial bureaus, finance agencies, and banks in jointly optimizing environmental and economic improvement. This forced all involved to search for least costly solutions to pollution.

Commitment of key policy-makers and top political leaders went hand in hand with merit-based and goal-driven bureaucracies, negotiated consensus building decision-making processes, and an ability to integrate environmental considerations into the unique decision-making structures and institutions used to guide the technological capabilities building activities of private sector firms in these economies. Bureaucrats in city governments, environmental, economic development, and industrial policy agencies were first and foremost highly trained goal-oriented pragmatic problem solvers. They possessed substantial independence or autonomy from organized interests in civil society, including business interests. This autonomy made it possible for those in government to devise and implement trial and error step-by-step

environmental programs and policies to solve real practical pollution problems.

Government officials in these countries also benefited from what Evans (1995) labels embedded autonomy—or autonomy based on institutionalized channels of communication with the private sector. Those channels facilitated information gathering that helped lower the costs of abatement while promoting the development of mutual trust. Because policy-making in East Asia requires negotiated consensus in which no one or no agency 'loses face', both regulators and industrial promoters tended to compromise by searching for and agreeing on least costly solutions to pollution. Finally, environmental agencies, economic development agencies, and industrial policy agencies found ways to integrate environmental considerations into well-established decision-making processes governing economic and industrial development.

Except for Singapore, those in regulatory and other government agencies committed to environmental improvement also took advantage of growing public criticism of 'grow first, clean up later' environmental strategies. But how they did so varied. Sometimes, as in Malaysia, regulatory agencies cracked down on polluters following highly publicized pollution incidents that strengthened their role at the expense of firms and economic agencies that wanted a more go-slow approach to environmental improvement (Rock 2002*a*). Sometimes, as in Taiwan Province of China, regulatory agencies used relationships with part of the public, including academics, research institutes, and non-governmental organizations, over a new issue, namely environmental clean up, to good effect by engaging the public in ambient and environmental standard setting and in environmental impact assessments for large projects. And sometimes, as in China and Taiwan Province of China, regulatory agencies channeled public complaints through citizen 'hotlines' to strengthen their role against those proposing a more go-slow approach to environmental clean up and to demonstrate to others (mayors and other government officials) that they were responding to citizen complaints (Rock 2002*b*).

Unwavering leadership commitment to environmental clean up, merit-based and goal-driven bureaucracies with embedded autonomy, opportunistic behavior on the part of regulators, and integration of environmental considerations into the institutions of industrial policy proved to be a particularly potent mix to drive environmental improvement in the rapidly industrializing countries of East Asia. Unfortunately, many of these elements appear to be lacking in most of the other developing countries. Not only is there little evidence that top leaders in most of the other developing countries are committed to environmental improvement, most public sector bureaucracies do not have the tendency to be as merit-based, pragmatic, or goal driven as the countries in East Asia. To make matters worse, those bureaucracies have substantially less technical capacity and less embedded autonomy, particularly from business, and they are fraught with

more or less patron–client ties that reinforce rent-seeking, rather than development-oriented behaviors. This is particularly true of industrial policy agencies, such as ministries of industry, boards of investment, and public sector science and technology institutes. Because of this, reformers in government, particularly economists, with support from the World Bank and the International Monetary Fund (IMF), are striving hard to dismantle the traditional selective instruments and institutions of industrial policy in these countries. Trade regimes are being liberalized, subsidized-directed credit programs are or have been largely dismantled, lists of promoted industries are being whittled down, and promotional privileges are being discarded in favor of simple market-driven outcomes.

This could lead one to conclude that there are few opportunities, if any, for driving environmental improvement in any of these countries until and unless underlying conditions become more favorable. This conclusion is considered unwarranted, especially since China has demonstrated that even when national-level considerations appear unfavorable, there may be real opportunities to engage in local environmental improvement. This is particularly clear in the case of China's city-level environmental rating, ranking, and public disclosure program. Conditions for success are greater in China's larger, richer, coastal cities than in smaller, poorer, inland cities. Mayors in these cities are more committed to environmental improvement, public pressure is greater, and bureaucracies are stronger, technically more sophisticated, and more goal driven. Not surprisingly, the larger, richer, coastal cities have made much more environmental progress than the smaller, poorer, inland cities. This also appears to be true of China's water pollution levy. Richer provinces appear to have used the levy to affect the polluting behavior of firms, while poorer provinces have been less prone to do so (Wang and Wheeler 1996).

Something similar has happened in Indonesia where a progressive mayor in a relatively large and rich coastal city took advantage of a highly publicized pollution incident to implement a city-level monitoring and inspections program of major industrial facilities within the city (Chapter 4; Aden and Rock 1999). This occurred against the backdrop of a weak national environmental agency that has had relatively little success in improving ambient environmental quality. In another important instance, even this weak national agency was able to garner enough high-level political support, including that from the president, to design and implement a unique public disclosure program that monitored and disclosed, through a simple color coding system, the environmental performance of major industrial water polluters (Vincent *et al.* 2000). What this means is that attempts to support policy integration have to be based on local-level knowledge to identify the best opportunities for intervention. This suggests the need for strong local partners and for highly targeted reconnaissance missions in individual countries. Such missions should focus on identifying local policy integration

'champions', identifying stakeholders in environmental, economic development, and industrial policy agencies that might be willing to engage in environmental improvement, and assessing the extent to which public pressure can be exercised. A start would have to be made by looking at the national picture, moving down to provincial- and city-level conditions in one or more provinces or cities. But it also requires looking at other potential opportunities, such as focusing on particular locales that are 'hot-spots' that have attracted the requisite attention and support. It could also involve working with others, such as industrial estate authorities, that are being pressed by local power holders, NGOs, and/or local communities to clean up pollution emanating from particular estates. While opportunities for policy integration will vary from country to country and from place to place, the central messages are clear—build relationships with like-minded local partners and engage in highly targeted reconnaissance missions that enable one to seize real targets of opportunity.

Because governments and government agencies in other developing countries are not as strong, capable, and goal driven as their counterparts in rapidly industrializing East Asia, policy integration may have to be less government centered. The alternative is to center policy integration on and in firms and their problems. The question this raises is what should less able and less autonomous government agencies do without overtaxing their capacity to design and implement new policies or open them to too much rent seeking? Since the central problem facing many firms in the other developing countries is increasing the capability of firms to import, adapt, and innovate on an increasingly sophisticated capital stock developed elsewhere, the most obvious point of entry is linking technological capabilities upgrading within firms with environmental capabilities building.

4

The Role of Environmental Regulatory Agencies in Sustainability: Korea and Indonesia[1]

4.1 Introduction

The first step, but by no means the last, in the process of improving the environmental performance of manufacturing plants, firms, and industries in East Asia requires the building and strengthening of traditional environmental regulatory systems. Without this, policy integration is not likely to work and without effective policy integration, governments in East Asia are not likely to be able to link environmental intensities reduction policies to the technological capabilities policies of economic and industrial development agencies. Because most governments in East Asia pursued 'grow first, clean up later' environmental strategies and because traditional economic and industrial development agencies are so closely linked to their counterparts in private industry, many (Lee and So 1999; Lohani 1998; Smil 1997; Eder 1996; Bello and Rosenfeld 1992) are skeptical of the ability of governments in this region to build and sustain traditional environmental regulatory agencies. But there is growing evidence that numerous governments in this region, including in Singapore, Malaysia, and Indonesia in Southeast Asia and Taiwan Province of China, China, and Korea in Northeast Asia have made significant progress in building traditional command and control regulatory agencies (Rock 2002*a*; Aden *et al.* 1999).

Everywhere in East Asia, this was and is a lengthy, costly, difficult, contentious, and time-consuming process. The speed and alacrity with which governments succeed depends on an intricate interplay of international pressures, the nature of domestic politics, the capacity and capabilities of

[1] This chapter draws extensively from J. Aden and M. T. Rock (1999), 'Initiating Environmental Behavior in Manufacturing Plants in Indonesia', *Journal of Environment and Development*, 8(4), 357–75 with permission from Sage Publications and on J. Aden, K. -H. Ahn, and M. T. Rock (1999), 'What is Driving the Pollution Abatement Expenditure Behavior of Manufacturing Plants in Korea?' *World Development*, 27(7), 1203–14 with permission from Elsevier.

the state, and the rapidity with which new ideas about the environment spread (Rock 2002*a*). Sometimes, as in Taiwan Province of China, international pressures associated with the loss of diplomatic recognition and citizen pressures associated with democratization have exerted powerful influences on the ruling party, the KMT, to build a strong and capable environmental regulatory agency as a way of demonstrating to the world and Taiwan's citizens that the government was environmentally responsible (Rock 2002*a*). Other times, as in Singapore, a benevolent despot committed to creating a clean and green Singapore used the powers of government and a highly capable bureaucracy to create a credible environmental agency (Rock 2002*a*). At still other times, as in Malaysia, the ruling party, the United Malays National Organization, used its control over the government and the state bureaucracy to craft an innovative solution to a particularly pressing environmental problem associated with the production and export of processed palm oil (Rock 2002*a*). One of the consequences of that action was the creation of a reasonably well resourced and competent environmental agency. But no country in this region has been able to improve the environmental performance of industry without building a credible regulatory agency that has the resources and the political and technical capabilities to set and enforce ambient and emissions standards.

We demonstrate this by tracing the development of environmental regulatory agencies in two of East Asia's newly industrializing economies—the Republic of South Korea and Indonesia—and by linking differences in the development paths of their regulatory agencies to one commonly used measure of the environmental performance of manufacturing plants—their investment in pollution control equipment. We focus on these two countries because they are at opposite ends of East Asia's rapidly developing and industrializing economies. In 1960, Indonesia was one of East Asia's poorest and least developed economies. Despite an impressive growth record since 1965, income per capita in Indonesia in 2002 was the lowest—at roughly $1,100—among the East Asian newly industrializing economies. Korea started its rapid development from a much higher base (income per capita in 1960 was roughly $1,300) and it grew much faster than Indonesia (World Bank 2004). This enabled Korea to join the OECD in 1996 and to achieve a much higher living standard (approximately $14,000 in 2002) than Indonesia (World Bank 2004). Korea also has a longer and more successful experience with democracy than Indonesia and it has a more capable state. Not surprisingly, it has been more successful than Indonesia in building a capable and credible environmental regulatory agency. While Indonesia has been somewhat less successful in getting manufacturing plants to invest in pollution control, it too has had some modest successes. But this did not come easily to either Korea or Indonesia.

4.2 Development of Regulatory Agencies in South Korea and Indonesia

Both Korea and Indonesia pursued 'grow first, clean up later' environmental strategies. Korea's first major environmental law, the Environmental Preservation Act, was not enacted until 1977. This law established a broad regulatory framework for: setting environmental standards; maintaining air and water quality; controlling noise and vibration; managing solid and hazardous wastes; and protecting the natural environment. The government created an Environmental Management Bureau in the Ministry of Public Health (MOPH) to implement the new law. In 1980, this bureau was upgraded to a sub-cabinet agency, the Environment Administration (EA) of the MOPH. Initially, local authorities were vested with enforcement responsibilities but in 1987, six regional offices of the EA were created and charged with enforcement. For a variety of reasons, neither local authorities nor the regional offices of the EA engaged in much inspection or enforcement. Democratization and growing public concern for the environment ultimately led to the creation of a cabinet-level Ministry of the Environment in 1990. This was followed by the enactment of a new set of environmental laws, including a new basic framework law, the Basic Environmental Policy Act (BEPA). The BEPA added to existing legislation by, among other things, endorsing the polluter pays principle and establishing joint and several liability of industrial plants for pollution damages. In 1990 and 1991 the National Assembly passed legislation governing air, water, hazardous chemicals, and solid wastes. Another new statute established a Central Environmental Dispute Co-ordination Committee to mediate environmental damage claims. Following a serious pollution incident in the Nakdong River, the Assembly passed the Special Act to Punish Environmental Crime in 1991. Finally, in 1993 an Environmental Impact Assessment Act was established. With this, the basic legal framework for environmental regulation in Korea was set. Implementation of the country's new environmental laws was vested with a cabinet-level Ministry of the Environment (MOE). To assist it, the MOE created six regional offices and made them responsible for permitting, monitoring, and enforcement. The MOE was also given responsibility for managing the public sector Environmental Management Corporation (EMC). The EMC finances, constructs, and operates wastewater treatment facilities in industrial estates. The MOE is assisted by KEI (the Korea Environmental Institute) which does research on environmental policy and environmental impact assessment; the National Institute for Environmental Research (NIER) which does ambient environmental monitoring for the MOE; and a Central Environmental Policy Advisory Committee (CEPAC). CEPAC is composed of prominent representatives from business, government, and

the academic/research community and it is organized into 13 subcommittees. It advises the MOE on ambient and emissions standards. Although the MOE's ambient standards are not legally binding, its emissions standards are. Both broadly mirror practices in the OECD. Because media-specific emissions standards have potentially important economic impacts on polluters, the MOE consults with other ministries, particularly the Ministry of Commerce, Industry, and Energy (MOCIE) in setting those standards.

To date, implementation of environmental statutes has followed a command and control approach based on quality or concentration standards. Facilities expecting to emit pollutants are required by law to obtain separate permits for air, water, and noise from the MOE. Permits are issued on the basis of facility size (the tons of coal equivalent used per year and cubic meters of waste water discharged per day). When emissions are expected to exceed legal limits, polluting plants are required to install 'certified' pollution abatement equipment. Once a polluting facility is authorized to begin operations, it is required to operate and maintain its pollution control equipment and to self-monitor the performance of abatement equipment. This includes keeping records of the time periods of operation of abatement equipment, the amount of pollutants emitted, the maintenance of the abatement equipment, and the person in charge. Self-monitoring records are to be kept for three years. Facilities which cannot meet emissions standards must report this to authorities. Those who do so are exempt from administrative and criminal sanctions, but Korea's non-compliance penalties apply.

Ultimately, the force of the country's environmental regulations depends on a combination of public and community pressure, the law-abidingness of polluters, and whether polluters believe that the MOE has the monitoring and enforcement capacity to credibly threaten those who violate emission standards. All three have undergone substantial change. As Korea's middle class has expanded, public concern for the environment has grown. In 1982 only 14% of those surveyed nationally thought the environment important. By 1990, this number had risen to 64% (Eder 1996: 75). This occurred in tandem with another shift in public opinion of equal import. In 1982, 68% of those surveyed thought the government was working to protect the environment. By 1990, this dropped to 24% (ibid. 76). Public reporting on the environment experienced a similar surge. By one account (ibid. 77), there were only 479 environmental stories in major newspapers in 1982. By 1992, this had jumped to 8,884. One consequence of all of this has been development of effective NIMBY (not in my backyard) campaigns by local activists, communities, and NGOs to forestall infrastructure projects (ibid. 107). Another manifestation of growing public concern for the environment is the growth in public complaints regarding environmental damage. These were virtually unheard of prior to democratization. Since then there has been an explosion in complaints. In two recent serious incidents (Nakdong River phenol spills in 1991 and 1994), the public outcry was so strong that the Minister and Vice

Minister of the Environment and the chairman of the corporation (the Doosan group) responsible for the spill were forced to resign.

This change in public attitudes toward the environment and the public pressure attending it has no doubt strengthened the ability of the MOE to develop the capacity to maintain an ambitious monitoring, inspections, and enforcement program. It appears to have made major progress over its predecessors in this area. Part of this is due to significant increases in resources allocated to the MOE. In 1980, the staff of the Environment Administration was 238 and its budget equaled 343 hundred million won. By 1994, the MOE had a staff of 1,100 and a budget of 2,697 hundred million won. Because of this, the MOE and its regional offices have been able to undertake a substantial basic accounting of the number, kinds, and location of major air and water polluters.

By 1993, the MOE had identified 25,808 major facilities emitting pollutants into the air (MOE 1994: 11). These facilities have been identified by location (province), pollutant (SO_2, NO_x, CO (carbon monoxide), HC (hydrocarbons), and TSP), and source (heating, industry, transportation, power generation) of pollutant. Plants emitting pollutants into the air have been classified into four types (blue, green, yellow, red) based on the scale of operations and the frequency of violations. Larger facilities and those found in more frequent violation of standards have been rated either yellow or red and are inspected more frequently. The MOE now routinely inspects about 25,000 air pollution emitting facilities per year. Inspections of these facilities increased from 32,921 in 1989, to 52,566 in 1991 and 57,854 in 1993 (ibid. 23). Of these, roughly 10% per year were found to be in violation of emissions standards. The regional offices of MOE responded to violations by issuing warnings; ordering improvements; suspending operations; shutting down operations; and recommending to prosecutors that criminal indictments be brought. Actual indictments equaled 553 in 1989; 1,655 in 1991; and 1,942 in 1993 (ibid.).

Industrial wastewater dischargers have been identified by location (province/river) and industry sector. Wastewater emitters are classified into one of four color categories (blue, green, yellow, and red) based on the status of their abatement facilities and the results of inspections. Facilities with completely installed and operating abatement equipment and with few 'unintentional' violations are rated blue or green. Those with incomplete abatement facilities and/or more, or more severe, and/or intentional violations are rated yellow or red. Inspection intensity varies with a facility's rating. Blue facilities tend to be inspected once per year, green facilities two times per year, yellow three, and red four times per year. The number of wastewater discharge inspections has increased from 25,624 in 1988, to 61,639 in 1990 and 72,239 in 1993. Violations of emissions standards averaged around 20% in 1988–89 and 10% in 1992 and 1993. MOE inspectors responded to wastewater emissions standards violations by issuing improvement orders; suspending operations; revoking permits; and seeking criminal prosecutions.

One other element of environmental policy deserves mention. Since 1983 environmental regulators have imposed a non-compliance penalty on facilities found in violation of air or water emissions standards. The penalty is based on the duration and severity of the violation. The basic charge is a flat fee that varies with facility size. In addition, repeated violations are charged an additional penalty. The current penalty rate is 1.3 times the base rate for the second offense; 1.3 times 1.3 (1.69) for the third offense; and 1.3 times 1.3 times 1.3 (2.19) for the fourth offense, and so on. While there is some question as to whether the non-compliance penalty has a deterrent effect, there is little doubt that it is a substantial revenue raiser. In 1993, collected non-compliance charges totaled 13.5 billion won.

A range of circumstantial evidence suggests that public pressure and regulatory actions are having some effect on the behavior of polluters. Between 1985 and 1993 industrial process generated BOD increased by 2.7 times but BOD discharged into Korean rivers increased by only 20%. Time series data suggest that ambient air quality for several criteria pollutants (SO_2, NO_x, TSP, and CO) is improving (O'Connor 1994: 106). And survey data on firm-level pollution control expenditures suggest that firms are making substantial investments in pollution control. Between 1991 and 1993, investments in pollution control averaged 7.2% of total investment.

Environmental law, policy, and regulation in Indonesia have evolved more slowly than in Korea. Efforts began with the government's preparations for the UN sponsored Conference on the Living Environment in Stockholm in 1972. Following this in 1978, the government established a Ministry of State for Development Supervision and the Environment (MSDSE). In 1982, the government passed landmark environmental legislation, the Act Concerning Basic Provisions for the Management of the Living Environment. This act institutionalized requirements for environmental impact assessments, empowered the MSDSE to coordinate environmental policy, granted provincial governors executive power over environmental matters within provinces, opened the way for development of new quality standards for protecting the environment, and explicitly assigned responsibility for cleaning up pollution to polluters (ibid. 71).[2] In 1983, the government created a cabinet-level State Ministry for Population and the Environment.

Despite these developments, by the mid-1980s, it was clear that Indonesia had not yet put in place the machinery for effectively monitoring and enforcing compliance with the country's emissions standards. This began to change when the State Ministry for Population and the Environment launched an innovative and voluntary pollution reduction program (PROKASIH) and when (in 1990) the president decreed the creation of a national environmental impact management agency, BAPEDAL, with the responsibility for

[2] However, the Act did not create the legal basis for the environmental ministry to set emissions standards and monitor and enforce them.

implementing the country's environmental laws and regulations. BAPEDAL took over responsibility for environmental impact assessment and PROKASIH, and launched its own creative monitoring and enforcement program (PROPER) (Afsah and Vincent 2000). More recently, the government began creating provincial-level environmental management offices (BAPEDALDA). By 1997, 16 BAPEDALDA were established.

Unfortunately, there is not much evidence to suggest that these developments have affected either the behavior of polluters or ambient environmental quality in Indonesia. The biggest problem is that direct and regular collection of field-level data on ambient environmental indicators in Indonesia is still quite limited. Regular monitoring of water and air quality is carried out in relatively few areas. These problems are compounded by a general lack of quality control in data collection and in laboratory analysis, by the use of outdated and inadequate laboratory equipment, by a shortage of well-trained staff, and by a lack of standardized protocols for monitoring and analyzing data samples.

In addition, the legal mandate for monitoring and enforcement remains weak. Only representatives from the Ministry of Industry and Trade have the authority to enter plants to monitor emissions. BAPEDAL continues to lack the legal authority to enforce emissions standards and it is not permitted to bring charges against polluters in the country's courts. This leaves enforcement in the hands of local police. Because of this, BAPEDAL has searched for creative ways to attack some of the country's worst ambient environmental quality problems. It has done this through the PROKASIH (Clean Rivers) Program and the PROPER Program, an environmental business rating program (Afsah and Vincent 2000).

4.3 The Survey Data

The picture presented above suggests that growing public concern over the environment and public pressure on polluters and on government regulators alongside a much strengthened Ministry of the Environment may be making a bigger environmental difference in Korea than it is in Indonesia. To gain a clearer sense of the interrelationships between plant-level abatement expenditures, regulatory actions, public pressure, and market pressure in Korea and Indonesia, two surveys of the environmental behaviors of manufacturing plants in Korea and Indonesia were carried out. The purposes of the surveys were to gather data on characteristics of plants, environmental behaviors of plants, exposure of plants to regulatory, community, and environmental market pressures (in Indonesia only), and use of government incentives by plants designed to help them purchase pollution control equipment. Results from the surveys were then used to assess the impact of each of these on plants' environmental behaviors.

In Korea, 92 manufacturing plants in two high polluting sectors (textiles and plastics/resins/petrochemicals) located in five different industrial estates in three regions (north, south central, and southeast) of Korea were surveyed. Fifty-three of the surveyed plants were in the textile sector and 39 were in the plastics/resins/petrochemical (PRPC) sector. The choice of locations reflected the prevalence of industrial estates, the major jurisdictions of the Korean Ministry of the Environment, and the location of industry in all of Korea's large urban areas.

The plant-level survey in Indonesia was limited to 110 manufacturing plants in four high polluting sectors (chemicals, food and beverages, textiles, and other, primarily wood processing) in the city of Semarang, a large industrial city on the north coast of Java (see Appendix 4A). Semarang was chosen for study for three reasons. First, it is a large (population of about 1.3 million) industrial city on the heavily industrialized north coast of Java. Because of this, the city is home to roughly 10% of all large and medium scale plants in Central Java Province. This provided relatively easy access to a large number of plants. Second, a highly charged water pollution case, the 1990–91 Kali Tapak incident, significantly increased environmental awareness in Semarang. This suggested that plants might be more sensitive than their counterparts elsewhere in Indonesia to pressures to abate pollution. Third, this case provided the mayor of the city with an opportunity to establish the Regional BAPEDAL of the City of Semarang. Since its inception, BAPEDALDA Semarang has conducted an industrial emissions monitoring program that reaches a majority of large and medium scale industrial plants in the city. BAPEDALDA Semarang also investigates and mediates industrial emissions complaint cases in the city and it issues warnings to plants that violate local emission standards.

Of the plants surveyed in Korea, almost 90% (81) had incurred some level of abatement expenditures. Of those 81 plants, 47 were in the textiles sector and 34 were in the PRPC. The average age of those plants was 16 years and ages ranged from 3 to 75 years. The average employment of plants was 353 employees with a range from 10 to 4,900 employees. Average sales were \$10.39 million with a range from \$152,000 to \$6.7 billion. Average annual expenditures (capital and operation and maintenance) for pollution abatement between 1988 and 1993 averaged \$1.1 million—with a range from \$612 to \$43.5 million. Approximately 90% of these plants (72) were fully owned by the Korean private sector.

As might be expected, these averages (Table 4.1) concealed large differences between textile and plastics/resins/petrochemical plants (PRPC). The average PRPC plant employed more than three and one half times as many people (607 to 168) as the average textile plant. Average sales in PRPC plants were a little more than 40 times larger (\$472 million to \$11.6 million) than those in textile plants. Average pollution abatement expenditures of PRPC plants were 38 times higher than those for textile plants (\$2.68 million versus

TABLE 4.1. Descriptive statistics for sample of manufacturing plants in Korea

	Mean		Std. Dev.		Max./Min.	
	Text.	PRPC	Text.	PRPC	Text.	PRPC
PAE	0.70t	2.68m	117t	7.48m	75t/1.2t	43.5m/612
EMP	168	607	215	888	1385/11	4900/10
AGE	16.1	15.5	11.3	7.4	75/3	30/3
S/E	79.3t	592.5t	130.7t	606t	901/2.6	2.8m/63t
OWN	0.91	0.85	0.28	0.35	1/0	1/0
GM	13.2	24.8	15.01	29.71	60/0	150/0
SN	5.49	9.17	7.17	11.74	36/0	51/0
SM	5.96	35.16	15.55	104.2	99/0	365/0
CP	0.32	0.68	1.29	1.57	8/0	8/0

Notes: *PAE* is annual pollution abatement expenditures in US$; *EMP* is plant-level employment; *AGE* is age of the plant; *S/E* is plant-level sales (US$) per employee; *OWN* is a dummy variable for ownership ($OWN = 1$ for domestically owned plants and $OWN = 0$ for any level of foreign ownership); *GM* is an index of government monitoring of a plant; *SN* is an index of government sanctions imposed on a plant; *SM* is a measure of plant-level self-monitoring of emissions; and *CP* measures community pressure on a plant to reduce emissions. Sample size for textiles is 47. Sample size for PRPC plants is 34. Entries ending in t are in thousands; entries ending in m are in millions.

$70,541). And a larger percentage of the PRPC plants with some level of abatement had some foreign ownership (15% to 8.5% for textile plants).

Because of these differences, we expected that the industry sector might be an important determinant of abatement expenditures. There were several other reasons for thinking that sector of plant might matter. The textile sector is a declining sector in Korea whereas the PRPC sector has been favored by government. This might make it easier for regulators to punish textile plants and harder for them to impose costly sanctions on PRPC plants. There is some evidence that something like this is happening in both Taiwan and Singapore. This is consistent with arguments made by Ayres and Braithwaite (1992: 5) to the effect that industry context often affects the behavior of both regulators and the regulated industry.

Of the 110 plants which comprised the data set for Indonesia, 31 (28%) were chemical plants, 28 (25%) were textile plants, 26 (24%) were food and beverage plants, while the rest were in other industries. The average plant in the Indonesia sample employed 322 people, was 16 years old, and had an average labor productivity of $78,222.[3] Forty percent (44) of these plants stated that they had made pollution control expenditures between 1991 and 1996.[4] Annual expenditures for pollution control were much lower than in

[3] We use an admittedly crude measure of labor productivity, sales per employee.

[4] This refers to answers to question 7 in Appendix 4A.

Korea, averaging \$15,000.[5] Thirty-six percent of the surveyed plants stated that they self-monitor emissions,[6] 17% stated that they reported self-monitoring results to BAPEDALDA Semarang,[7] while 21% reported that they had at least a nascent plant-level environmental management system (EMS).[8]

Not surprisingly, as in Korea, these aggregate numbers hide significant sectoral differences. While there was not much difference in the average age of plants across sectors (Table 4.2), the average textile plant had more employees (662) than chemical plants (171 employees), food and beverage plants (154 employees), and plants in the other category (303 employees). As expected, labor productivity in chemicals plants was higher (sales per employee equaled \$288,134) than in textile plants (sales per employee equaled \$14,883), plants in the other category (sales per employee equaled \$13,936), and food and beverage plants (sales per employee equaled \$6,837). There were also significant differences in pollution control expenditures across sectors. Those expenditures were lowest in food and beverage plants (\$1,016) and higher in chemical (\$10,114) and textiles plants (\$18,214).

Table 4.2. Descriptive statistics of plants by sector in Indonesia

	Chemicals	Textiles	Food & Beverages
ENVBEH1	0.58 (0.50)	0.25 (0.44)	31 (0.47)
ENVBEH2	\$10.1 (\$25.2)	\$18.2 (\$90.9)	\$1.0 (\$4.0)
ENVBEH3	3.0 (2.87)	1.35 (2.43)	1.53 (2.4)
ENVBEH4	0.35 (0.49)	0.18 (0.39)	0.12 (0.33)
EMPLOYMENT	171 (341)	662 (879)	154 (296)
AGE	16 (11)	15 (10)	15 (10)
SALES (\$) per *EMPLOYEE*	\$288 (1,351)	\$14.8 (45,791)	\$6.8 (7.1)
GMW	6.22 (4.9)	6.89 (7.0)	6.58 (9.89)
DFA	0.09 (0.30)	0.18 (0.39)	0.03 (20)
CP	2.06 (1.8)	1.96 (1.59)	2.23 (1.9)
BP	0.42 (0.95)	0.29 (0.66)	0.15 (0.54)

Notes: Numbers without parentheses are means; those with parentheses are standard deviations. *ENVBEH1*, *ENVBEH3*, *ENVBEH4*, and *DFA* are (1, 0) dummy variables as defined in the text. *ENVBEH2* is average annual pollution control expenditures in thousands of US dollars. *EMPLOYMENT* is the number of employees. *SALES* per *EMPLOYEE* is sales in thousands of US dollars. *GMW*, *CP*, and *BP* are weighted dummy (1, 0) variables as defined in the text.

[5] This was obtained from answers to questions 12 and 13 in Appendix 4A.

[6] This result was obtained from answers to question 14 in Appendix 4A.

[7] This result was obtained from answers to question 15 in Appendix 4A.

[8] Plants with nascent EMS systems stated that they either had environmental staff, engaged in environmental audits, or had quantitative pollution reduction goals. Actual questions asked appear as questions 16, 17, and 18 in Appendix 4A.

What do we know about the level of exposure of these plants in Korea and Indonesia to regulatory, community, and market pressure? We answered this question by constructing a number of indices of plant-level exposure to each of these. Because government monitoring, inspection, and sanctions were more intrusive in Korea than in Indonesia, we constructed an intensity of government monitoring variable and an intensity of sanctions variable for our Korean plants. Design of questions to capture these was based on actual Korean experience and suggestions in Ayres and Braithwaite (1992: 35–9) that regulation works best when regulators have at their disposal a hierarchy of enforcement strategies (sanctions) and a hierarchy of intervention (monitoring and inspection) strategies.

The hierarchy of government monitoring (*GM*) variable was constructed by weighting and adding up the frequency of monitoring and inspection visits. The actual GM index was constructed as follows:

$$GM = (FGM) + 1.5^*(FGINS) + 2^*(UNINS)$$

where FGM = the frequency of government monitoring visits in the last 12 months; $FGINS$ = the frequency of government inspections in the last 12 months; $UNINS = 1$ if inspections were unannounced and 0 otherwise.

A regulatory sanctions index (*SN*) was constructed as follows:

$$SN = (VW + ERO) + 2^*(NCP) + 3^*(FI) + 4^*(CRIM) + 5^*(CLOSE)$$

where VW = number of verbal warnings; ERO = number of emission reduction orders; NCP = number of non-compliance charges; FI = number of other fines; $CRIM$ = number of criminal actions requested by MOE; $CLOSE$ = number of temporary closures.

Ayres and Braithwaite (1992: 5) also suggest that responsive regulators start relationships with regulated firms by assuming that they will cooperate with regulators. We used two variables—actual abatement expenditures and the frequency (over the past 12 months) with which plants reported self-monitoring (*SM*) results to regulators—as measures of cooperation.

With regard to community pressure, we were interested in assessing the impact of direct community pressure on plant-level pollution abatement expenditures. Several case studies (Hsin-Huang 1998; Cribb 1990; Khator 1991) suggest that at least some polluters respond positively to complaints, protests, or requests by neighbors to reduce emissions either by installing pollution control equipment or by agreeing to do so in a negotiated pollution control agreement. The effect of community pressure on emissions has been confirmed in several statistical studies (Hettige *et al.* 1996; Pargal and Wheeler 1996) which found that proxies for direct community pressure (community income levels and education levels) have significant effects on plant-level emissions. But, as far as we know, no one has tested for the impact of direct community pressure as defined above on either a plant's abatement expenditures or its emissions. Because of this, we constructed a simple

straightforward intensity of community pressure variable (*CP*) for our Korean plants by summing up the number of community requests made of plants to abate pollution and the number of pollution control agreements that exist between a plant and a given community. Thus we defined community pressure (*CP*) as

$$CP = NCRPA + NPCA$$

where $NCRPA$ = the number of community requests made of a plant to abate pollution and $NPCA$ = the number of pollution control agreements between a plant and a community.

One final point about the Korean survey data deserves mention. As can readily be seen in Table 4.1, there appear to be significant sectoral differences in intensity of exposure to government monitoring, regulatory sanctions, self-monitoring, and community pressure. The mean value of the intensity of government monitoring (*GM*) is 24.8 for PRPC plants and 13.2 for textile plants. The mean value of the intensity of regulatory sanctions is 9.1 for PRPC plants and 5.48 for textile plants. The average frequency with which plants report self-monitoring results to regulators is 35.1 for PRPC plants and 5.96 for textile plants. The mean value of exposure to community pressure is 0.68 for PRPC plants and 0.32 for textile plants. Said another way, a higher percentage of PRPC plants have been exposed to regulatory and community pressure. The intensity of exposure to each of these is also higher for PRPC plants.

What do we know about the level of exposure of our Indonesian plants to regulatory, community, and market pressures and access of plants to financial/fiscal incentives to install pollution control equipment? We answered this question by constructing a number of indices of plant-level exposure to each of these. With respect to regulatory pressure we were interested in a variable measuring a plant's exposure to the intensity of government monitoring/sanctions. As in the Korean survey instrument, questions to capture this were based on actual experiences in Indonesia and suggestions in Ayres and Braithwaite (1992: 35–9). The latter have argued that regulation works best when regulators have at their disposal a hierarchy of monitoring and sanctions strategies. Since BAPEDALDA Semarang has only a limited number of options for monitoring and enforcing emissions standards, we developed a measure of government monitoring/sanctions that captured this by creating a composite monitoring/sanctions index, labeled *GMW*, as follows:[9]

$$GMW = FGM + 2^{*}WN$$

[9] The actual questions asked appear as questions 41 and 42 in Appendix 4A. Sanctions are limited to issuing warning letters. In Semarang, these can come from either BAPEDALDA Semarang or from the mayor.

where FGM = the frequency of government monitoring over the past 12 months and WN = the number of warning letters the plant received over the past 12 months.

A plant's exposure to community pressure (CP) was captured by weighting and summing answers to questions designed to assess its indirect exposure to community pressure, that is, the plant manager's knowledge of other plants' exposure to such pressure (weight = 1) and the plant's direct (own) exposure to community pressure (weight = 2).[10] A plant's exposure to environmental market (buyer) pressure (BP) was captured by weighting and summing answers to questions designed to measure its indirect exposure to market pressure from buyers (BP), that is, the plant manager's knowledge of other plants' exposure to such pressure (weight = 1) and its (own) direct exposure to pressure from buyers (weight = 2).[11] Since the government of Indonesia, unlike the government of Korea, offers plants financial and fiscal incentives to purchase pollution control equipment, we created a dummy variable (DFA = 1 if a plant received tax breaks, duty exemptions for the import of pollution control equipment, and/or subsidized loans to purchase such equipment and DFA = 0 otherwise) to measure the degree to which plants took advantage of these incentives when purchasing pollution control equipment.[12]

Exposure to each of these 'pressures' in our Indonesian plants varies by sector, but, for the most part, the differences are not great. Ninety-seven percent of textile plants have been exposed to government monitoring/warnings. The comparable figures are 94% for chemical plants, 90% for food and beverage plants, and 76% for plants in the 'other' category. Seventy-six percent of the textile plants have been exposed to community pressure, while 74% of the chemical plants, 80% of the food and beverage plants, and 60% of those in the 'other' category have been so exposed. With respect to environmental pressure from buyers, 18% of the textile plants have been exposed to such pressure, while 22% of chemical plants, 10% of food and beverage plants, and 16% of plants in the 'other' category have been exposed to buyer pressure.

4.4 Econometric Tests

The survey data for Korean manufacturing plants suggest that manufacturing plants in Korea have made significant expenditures for pollution abatement, and are subject to substantial regulatory actions and community

[10] This was done by weighting and summing answers (Yes = 1, No = 0) to questions 19 through 28 in Appendix 4A.

[11] This was done by weighting and summing answers (Yes = 1, No = 0) to questions 29 through 34 in Appendix 4A.

[12] The *DFA* variable was constructed from answers to questions 35 and 36 in Appendix 4A.

pressures. The survey data for Indonesia suggest that the sample of manufacturing plants in Semarang engages in significant environmental behaviors, but that expenditures for pollution control are low, particularly when compared to expenditures in our sample of Korean plants. The Indonesian data also reveal that manufacturing plants in Indonesia are subject to relatively low levels of direct regulatory, community, and buyer pressure, amplified, in the case of community and buyer pressures, by higher levels of indirect pressure. These differences within each sample made it possible to formally test hypotheses regarding the impact of regulatory and community pressure on plant-level pollution abatement expenditures in Korea and Indonesia. Statistical tests were based on a model developed by Hettige *et al.* (1996), Pargal and Wheeler (1996), and Pargal *et al.* (1997). Like them, we test for the influence of plant characteristics (size of plant, age of plant, plant-level productivity, and ownership of plant) and community pressure on plant-level expenditures on pollution abatement.

But we make several basic amendments to their model. First, instead of focusing on emissions, our dependent variable is plant-level expenditures (annual average capital expenditures plus annual average operation and maintenance expenditures) for pollution abatement. Thus we ask, what drives manufacturing plants in Korea and Indonesia to spend resources on pollution control? Second, we measure community pressures on plants directly in Korea and Indonesia rather than through proxies (community-level incomes and/or education levels) as they do. Third, we test for the direct impact of formal regulatory pressures on plant-level abatement expenditures in both countries.

Because of differences in the legal and technical capabilities in the regulatory agencies in Korea and Indonesia and corresponding differences in regulatory strategies, we developed two distinct models of the regulatory process and their impact on our sample of plants.

It appears to us that regulators in the Korean Ministry of the Environment treat regulated plants in a 'tit-for-tat' (TFT) way as suggested by Ayres and Braithwaite (1992), so we develop an admittedly crude test of a TFT regulatory strategy. Ayres and Braithwaite argue that a TFT regulatory strategy, or what they also call responsive regulation, differs from traditional regulation by recognizing that sometimes firms and industries effectively self-regulate. When this happens, they propose that regulators complement deterrence (sanctions) with gentle persuasion and cooperation. But once firms fail to cooperate, regulators should fall back on deterrence. Ayres and Braithwaite (1992: 19–25) also hypothesize that a TFT strategy works best when regulators have at their disposal a range of credible and increasingly intrusive regulatory strategies and a range of equally credible and increasingly costly sanctions. In this view, deterrence works best to stimulate cooperation and compliance when regulators use increasingly graduated responses to non-compliance.

We incorporate cooperation (the first part of TFT) into our model by hypothesizing that regulators 'go light' on Korean plants (by sanctioning them less) the more those plants abate pollution by investing in pollution control expenditures and the more they report findings from their own self-monitoring of emissions to regulators. We incorporate graduated responses to repeated non-compliance (the second part of TFT) by using the weighted indices of government monitoring (*GM*) and regulatory sanctions (*SN*) as independent variables in a model of formal regulation.

More precisely, we tested the following simultaneous two equation model:

$$PAE = f(EMP, AGE, SALES/EMP, OWN, SN, CP) \qquad (1)$$

$$SN = f(PAE, GM, SM) \qquad (2)$$

where *PAE* is annual pollution abatement expenditures in US dollars; *EMP* is plant-level employment, a proxy for plant size; *AGE* is the age in years of the plant; *SALES/EMP* is sales (in US dollars) per employee of the plant—an admittedly crude measure of plant productivity. *OWN* is a dummy variable of whether the plant is owned domestically ($OWN = 1$) or by foreigners

TABLE 4.3. Two-stage least squares regression equations on Korean plants

	Log(*PAE*)	*SN*
Const.	−2.76	2.98
Log(*EMP*)	1.01	
	(7.08)***	
Log(*AGE*)	−0.29	
	(−1.20)	
Log(*SALES/EMP*)	0.73	
	(6.44)***	
OWN	0.72	
	(1.85)**	
SN	0.046	
	(1.94)*	
CP	0.17	
	(2.14)**	
Log(*PAE*)		0.0005
		(0.59)
GM		0.24
		(3.62)***
SM		−0.013
		(−2.17)**
Adjusted R^2	0.69	0.31
Chow *F* Statistic	1.03	0.76

Notes: Numbers in parentheses under regression coefficients are *t* values; *** significant at the 0.01 level; ** significant at the 0.05 level; * significant at the 0.10 level.

($OWN = 0$ for any level of foreign ownership). *SN* is an index of the intensity of government sanctions imposed on polluters for failing to meet emissions standards. *CP* measures community pressures on polluters (the sum of the number of community requests of plants to abate pollution plus the number of pollution control agreements between plants and communities). *GM* measures the intensity of government monitoring of plants, and *SM* reflects the frequency of self-reporting of emissions by plants to regulators.

Equation (1) in Table 4.3 estimates the impact of plant characteristics, regulatory sanctions, and community pressures on abatement expenditures. Equation (2) in Table 4.3 estimates the determinants of regulatory sanctions. In equation (1), we expect pollution abatement expenditures to be a positive function of plant size, productivity, community pressure and sanctions, and a negative function of plant age and ownership. In equation (2), we expect sanctions to vary negatively with the frequency of plant-level reporting of self-monitoring results to regulators and with current abatement expenditures. What this means in practice is that, all other things being equal, we expect regulators to 'go light' on firms that are cooperating with regulators (those with higher levels of abatement expenditures and higher levels of self-reporting of emissions). All other things being equal, we expect sanctions to vary positively with the intensity of government monitoring.

Because plant-level abatement expenditures and regulatory pressure (sanctions) for our Korean plants are simultaneously determined in a two equation model, estimation of both the abatement expenditure equation and the sanctions equation is by two-stage least squares (TSLS).[13] Except for the dummy variable on ownership (*OWN*) and the count variables (*GM*, *SN*, *SM*, and *CP*), estimation is of log-log regressions. Because it is reasonable to suspect that government monitoring (*GM*), self-monitoring (*SM*), and community pressure (*CP*) might also be simultaneously determined, Hausman (1978) specification tests were used to test for possible endogeneity of those variables. Chi-square tests revealed that each of those variables can be treated as exogenous and that is how they are treated here. Because Chow *F* tests indicated that there were not significant differences between the sectors, both equations were estimated for the full sample.

Results appear in Table 4.3. In addition to reporting regression coefficients, *t* tests, and adjusted R^2, we also report results of tests for specification error and for heteroskedasticity. As is well known, the latter tends to be quite common in cross-section estimation. Specification error might be an important problem if some or all of the cross-plant variation in abatement expenditures is due to unmeasured differences in production processes across plants. Since our sample includes a wide range of intra-industry differences within each sector, this might, in fact, be the case. While we were unable to identify a

[13] For this, the variables *EMP*, *AGE*, *SALES/EMP*, *OWN*, *GM*, *SM*, *CP*, and five location dummy variables (*LOC1*, *LOC2*, *LOC3*, *LOC4*, *LOC5*) are used as instruments.

proxy variable to allow us to include a measure of differences in production processes in equation (1), we take some comfort in the fact that the Ramsey Reset *F* test, a widely used test for specification error, suggests that neither equation (1) nor equation (2) appears to be subject to specification error. Finally, even though heteroskedasticity was not a problem, White's heteroskedasticity-consistent standard errors are reported.

What did we find? Starting with the abatement expenditure equation (equation (1) in Table 4.3), plant-level pollution abatement expenditures are positively associated with plant size, plant-level productivity, and a dummy variable for ownership ($OWN = 1$ for domestic ownership). Each of these variables is statistically significant. Except for the regression coefficient on ownership, these findings are broadly consistent with those reported elsewhere (Hettige *et al.* 1996). The positive relationship between abatement expenditures and ownership is puzzling because it suggests that domestically owned firms spend more on abatement than firms with some level of foreign ownership. While we do not have a good explanation for this finding, it may well reflect the low popular support for the country's large firms, or chaebols, that dominate industrial production and the responses by those firms to insulate themselves from public criticism. In addition, abatement expenditures are a positive function of the intensity of regulatory sanctions (*SN*). This suggests, as expected, that a hierarchy of sanctions exerts substantial influence on abatement expenditure behavior. Finally, community pressure also exerts a positive influence on abatement expenditures.

Taken together, these variables explain 69% of the variation in abatement expenditures across sampled firms. Calculation of normalized regression coefficients shows that plant size (beta equals 0.52) and plant-level productivity (beta equals 0.44) exert more influence on abatement expenditures than regulatory sanctions (beta equals 0.19), community pressure (beta equals 0.11), or ownership (beta equals 0.10). Moreover, a one standard deviation increase in regulatory pressure (*SN*) exerts twice as much impact on abatement expenditures as a one standard deviation increase in community pressure (*CP*).

Turning to the determinants of regulatory sanctions (equation (2) in Table 4.3), (*SN*) is a positive function of the intensity of government monitoring and a negative function of the frequency of plant-level self-monitoring reports. Both of these variables have the sign of the regression coefficient that was expected and they are statistically significant. The positive relationship between the intensity of government monitoring and the intensity of sanctions suggests that Korean regulators appear to have incorporated important elements of responsive regulation in their behavior. Both government monitoring and the sanctioning of plants reflect graduated responses. Tougher sanctions follow more intensive and intrusive monitoring. The negative relationship between frequency of reporting of self-monitoring results and sanctions suggests that Korean regulators may also be following a tit-for-tat

(TFT) strategy. That is, they 'go light' on those plants that more frequently report results to regulators. Taken together, these two variables account for 31% of the variation in regulatory sanctions. The normalized regression coefficients suggest that the intensity of government monitoring (beta equals 0.57) exerts substantially more influence on regulatory sanctions (*SN*) than self-reporting (beta equals 0.09).

Because the regulatory agency in Semarang, Indonesia has a less well-developed regulatory strategy, the approach to hypothesis testing in Indonesia was first to look directly at a range of environmental behaviors of plants in Semarang by initially asking whether or not plants invest in pollution abatement.[14] Among plants that invest in abatement, we ask why some invest more than others. This yields two separate dependent variables: one is a simple dummy environmental behavior variable (*ENVBEH1* = 1 if a plant has installed pollution control equipment between 1991 and 1996 and *ENVBEH1* = 0 otherwise); the other is the average annual pollution control expenditures (*ENVBEH2*) between 1991 and 1996.[15] Several other aspects of a plant's environmental behavior were plumbed. The survey asked, in a series of questions, whether or not plants engage in one of three environmental management practices.[16] From this, we created another dummy environmental behavior variable (*ENVBEH3* = 1 if the plant has any environmental staff, commissions environmental audits, or has quantitative pollution reduction targets and *ENVBEH3* = 0 otherwise). Finally, we constructed a 'count' environmental behavior variable (*ENVBEH4*) that simply added up dummy variable (1, 0) scores on eight other dummy variables.[17] By focusing on these specific plant-level environmental behaviors, we are asking how plants have responded with specific environmental actions to regulatory, community, and environmental market pressures.

Given the lack of legally binding monitoring and enforcement capabilities in BAPEDALDA Semarang as well as the lack of legally mandated emissions standards for particular industries, the estimation strategy for the Indonesian plants is noticeably more ad hoc. Because characteristics of plants (size, age of plant, productivity, ownership, and industrial sector of plant) have been shown to affect a plant's environmental behavior (Hettige *et al.* 1996), we included measures of these variables in our statistical analysis. More specifically, we hypothesized that because large plants (as measured by employment or *EMP*) are more visible than small plants, they engage in more environmental behaviors than small plants.[18] Because more productive plants

[14] The actual question asked appears as question 7 in Appendix 4A.

[15] The actual questions asked to arrive at estimates of average annual pollution control expenditures appear as questions 12 and 13 in Appendix 4A.

[16] The actual questions asked appear as questions 15, 16, and 17 in Appendix 4A.

[17] The actual questions asked appear as questions 7, 9, 10, 14, 15, 16, 17, and 18 in Appendix 4A.

[18] Large is defined as the number of employees (*EMP*) and information on this is provided by answers to question 45 in Appendix 4A.

(defined as sales per employee or *S/E*) have more resources to engage in a wider range of environmental behaviors, we expect them to engage in more of these than less productive plants.[19] Because foreign-owned plants (*OWN* =1 if there is any foreign ownership in a plant and *OWN* = 0 otherwise) are likely to be more vulnerable to criticisms from communities and scrutiny from regulators than domestically owned plants and because they may follow environmental practices of their home countries, they are expected to do more than domestically owned plants.[20] Because plants differ by sector (*CH* = chemical, *T* = textiles, and *FB* = food and beverages) in their pollution intensities, we also expect sector of plant to affect environmental behavior. That is, we expect plants from 'dirtier' sectors such as chemicals to invest more in pollution control than those in 'cleaner' sectors such as food and beverages.

Thus we estimated multiple regression equations of the following type:

$$ENVBEH_i = f(EMP, AGE, S/E, OWN, GMW, CP, BP, DFA, CH, T, FB)$$

where $ENVBEH_i$ represents one of the four different (i = 1, 2, 3, or 4) environmental behaviors described above. Independent variables included in estimated regression equations include characteristics of plants,[21] measures of regulatory actions (*GMW*), measures of community (*CP*) and environmental market pressures (*BP*), and a measure of whether or not a plant received fiscal/financial assistance to install pollution control equipment (*DFA*). Results of estimation appear in Table 4.4.

What did we find? Starting with whether or not a firm installed any pollution control equipment between 1991 and 1996 (*ENVBEH1* = 1 if a plant installed pollution control equipment and *ENVBEH1* = 0 otherwise), seven out of nine of our independent variables are statistically significant. This equation shows that the probability of a plant installing pollution control equipment is a positive function of plant size (*EMP*), age of plant (*AGE*), government monitoring/warning (*GMW*), community pressure (*CP*), and a plant's use of fiscal/financial incentives (*DFA*). Sector also matters. Chemical plants (*CH*) have a higher probability of investing in pollution control, while textile plants (*T*) have a lower probability of investing in pollution control. Taken together, these seven variables accounted for

[19] We used sales per employee as a crude measure of plant-level productivity. Actual questions asked appear as questions 45 and 46 in Appendix 4A.

[20] The actual ownership question appears as question 44 in Appendix 4A. We also asked questions about whether or not a plant's products were brand labeled and how much (what percentage) of a plant's products were exported. Actual questions asked appear as questions 2, 3, and 4 in Appendix 4A.

[21] Plant characteristics included sector of plant (*CH* = chemicals, *T* = textiles, *FB* = food and beverages, and *O* = other), age of plant (*AGE*), size of plant (measured by number of employees or *EMP*), who owned the plant (*OWN* = 1 for any foreign ownership and *OWN* = 0 otherwise), and a crude measure of plant-level productivity defined as sales per employee (*S/E*). Data on these were obtained from answers to questions 1, 43, 44, 45, and 46 in Appendix 4A.

TABLE 4.4. Regression equations on plant-level environmental behavior in Semarang, Indonesia

	ENVBEH1	*ENVBEH2*	*ENVBEH3*	*ENVBEH4*
Const.	−4.27	1.12	−5.88	−2.39
Log(*EMP*)	0.36	1.21	0.53	0.27
	(2.60)***	(4.15)***	(3.15)***	(3.34)***
Log(*AGE*)	0.50	−0.25	0.08	0.23
	(2.39)***	(−0.42)	(0.38)	(1.35)
GMW	0.05	0.04	0.03	0.03
	(2.85)***	(1.55)	(1.73)*	(3.18)***
DFA	1.12	0.03	0.52	0.83
	(2.43)***	(0.02)	(1.10)	(3.75)***
CP	0.2	−0.12	0.38	0.18
	(2.74)***	(−0.69)	(3.92)***	(4.07)***
BP	0.09	0.03	0.47	0.12
	(0.61)	(0.10)	(2.23)**	(2.03)**
CH	0.81	−0.48	1.58	0.81
	(2.14)***	(−0.57)	(2.64)***	(3.36)***
T	−1.14	−2.30	−0.14	−0.63
	(−2.38)***	(−2.08)**	(−0.23)	(−1.82)*
FB	0.15	−2.05	54	0.30
	(0.34)	(−2.7)**	(0.87)	(0.93)
$\bar{R}^2$	0.39	0.32	0.46	0.28

Notes: Numbers in parentheses under regression coefficients are t values; *** significant at the 0.01 level; ** significant at the 0.05 level; * significant at the 0.10 level.

roughly 40% of the variation in the probability of plants investing in pollution control. When the estimated equation was used to predict the probability that a plant installed pollution control equipment, the estimated equation correctly classified 82% of all plants.

With respect to estimation of the probability that a plant is engaged in internal environmental management practices (*ENVBEH3* = 1 if it is engaged in any of those practices and *ENVBEH3* = 0 otherwise), five of the independent variables are statistically significant. The *ENVBEH3* regression equation shows that the probability of a plant engaging in internal environmental management practices is a positive function of plant size (*EMP*), government monitoring/warning (*GMW*), community pressure (*CP*), and buyer pressure (*BP*). In addition, chemical (*CH*) plants have a higher probability of engaging in internal environmental management practices, while none of the other sector variables is statistically significant. Taken together, these five variables account for about one-half of the differences among plants in *ENVBEH3* practices. When this estimated equation was used to predict the probability that a plant engaged in one or more environmental management practices, the estimated equation correctly classified 96% of all plants.

Turning to regression estimation of the count-dependent variable *ENVBEH4*, results show that seven of the independent variables are statistically significant. The count variable, *ENVBEH4*, is positively affected by plant size (*EMP*), government monitoring/warnings (*GMW*), community pressure (*CP*), pressure from buyers (*BP*), and use of fiscal/financial incentives (*DFA*). In addition, chemical plants (*CH*) have higher count scores and textile plants (*T*) have lower count scores. These variables account for about a third of the variation in the count variable.

Taken together, these three equations suggest that plant characteristics, regulatory, community, and buyer pressure, and access to fiscal/financial incentives all exert significant influence on (*a*) the probability of a plant investing in pollution control; (*b*) the probability of it engaging in internal environmental management practices; and (c) the scope (count) of plant engagement in a wide range of environmental behaviors, including self-monitoring emissions and reporting results of self-monitoring to BAPEDALDA Semarang.

However, when we considered the impact of this same set of independent variables on plants' levels of pollution control expenditures (*ENVBEH2*), the results were different. In the equation on the log of annual average pollution control expenditures (*1ENVBEH2*), only three plant characteristics, size (*EMP*) and sector (*T* and *FB*) were statistically significant. This equation suggests that larger plants spend more on pollution control equipment than smaller plants, textile plants (*T*), and food and beverage (*FB*) plants. In fact, those three characteristics of plants accounted for almost one-third of the variation in pollution control expenditures of plants. This provides powerful evidence that plant characteristics, including industrial sector of plant, affect pollution expenditure abatement behavior. However, neither regulatory actions (*GMW*), community pressure (*CP*), buyer pressure (*BP*), nor fiscal/financial incentives (*DFA*) are statistically significant in this equation. In other words, increasing a plant's exposure to regulatory, community, or buyer pressure does not significantly increase a plant's expenditure on pollution abatement.

This raises the intriguing question. Why do regulatory, community, and buyer pressure exert statistical influence on *ENVBEH1*, the probability that a plant will make pollution control expenditures; on *ENVBEH3*, the probability that it will engage in internal environmental management practices; and on *ENVBEH4*, the extent (count) of those practices, but not on the amount (*1ENVBEH2*) of a plant's abatement expenditures? While we do not have a good answer to this question, it appears that initial investments in pollution control equipment and steps in setting up internal management mechanisms for pollution control may be preliminary actions (perhaps indicating an initial change in attitudes) to making substantial and ongoing expenditures for pollution control. These initial steps may also be part of a strategy to appease community and regulatory watchdogs.

But several pieces of evidence suggest that the former interpretation may be more important than the latter one. One is the distinction between direct and indirect pressure. Relatively few plants have experienced direct community pressure (13%) or direct environmental pressure from buyers (2%). But many of the plants in our sample are aware of these pressures. This seems to have been sufficient to get these firms to install some, but not much, pollution control equipment. On the other hand, a large percentage of the plants in our sample have had emissions monitored by government and have received warnings from government when emissions exceed standards. But because government does not have the power to legally force a plant to clean up, direct experience with monitoring/warnings apparently has not encouraged plants to engage in substantial abatement. Evidence of this can be seen by calculating the ratio of annual pollution control expenditures of a plant to its annual sales. Experience elsewhere shows that once environmental regulations begin to take hold, annual pollution control expenditures can average about one-half of 1% of sales, sometimes even more (O'Connor 1994: 181). In Semarang, both the mean and median values of pollution control expenditures as a percentage of sales for those plants making any expenditures on pollution control are effectively zero! The maximum ratio of annual pollution control expenditures to annual sales for plants undertaking any pollution control expenditures is less than 0.01%.

4.5 Implications of Findings

What are the policy implications of these findings? Four seem particularly important. First, plant characteristics matter. Larger plants engage in more environmental practices (in our Indonesian sample) and spend more on abatement (in our Korean and Indonesian samples) than smaller plants. This finding is not particularly surprising. Larger plants tend to use both more fuel and more water than smaller plants and so they need to build and maintain bigger and more costly air and wastewater treatment systems. Larger plants also tend to be more visible to both regulators and communities. This probably compels them to abate pollution, or at least to appear to be doing so by investing in pollution control and engaging in a variety of environmental practices. This may be particularly important if environmental reputation matters. Because smaller plants tend to be less visible, these considerations are probably less important for them.

Second, formal regulation matters. We know that stringent emissions standards and tough monitoring and enforcement by environmental agencies have made it possible to break the link between economic growth and pollution in developed countries. Because of this, it should not be surprising that something similar to this can occur in developing countries such as Korea and Indonesia once governments decide to get serious about reducing

pollution. Several other findings about regulation matter. We found some support for responsive regulation hypotheses in Korea. Our results suggest that Korean regulators appear to be acting as if plants know that failure to comply will be met by an increasingly intrusive monitoring program and escalating sanctions. In addition, it appears that government regulators in Korea may be engaging in important elements of a tit-for-tat (TFT) regulatory strategy. One other finding deserves mention: even in Semarang, Indonesia where the local regulatory agency has limited and weak monitoring and enforcement capabilities, government monitoring and enforcement have pushed manufacturing plants to engage in a limited range of environmental improvement activities. This suggests that when this agency develops the capability and legal authority for a more aggressive monitoring and enforcement program, plants in this city are likely to significantly increase their investments in pollution control.

Third, community pressure also matters. Because this has loomed large in the Japanese experience and because Japan has been looked to by others in Asia, including Korea and Indonesia, it is not surprising that community pressure matters. What is perhaps surprising is that it exerts an independent influence after taking the effect of plant characteristics and formal regulation into account. In fact, as far as we know, this is the first set of empirical studies to statistically demonstrate that direct community pressure can be an important component to a tough formal regulatory program. We have also found some evidence to suggest that external buyer or market pressure also matters, at least in Indonesia where we tested for it. Finally, while investment in pollution control in plants in Indonesia lags behind that of plants in Korea, the 'good news' is that plants in Semarang do respond to regulatory, community, and market pressures, and to government financial support. This leads them to invest in some abatement, to engage in some internal environmental management practices, to do some self-monitoring of emissions, and occasionally to report the results of self-monitoring to BAPEDALDA Semarang. This has three salutary effects. It provides an opportunity for plants to learn how to control pollution prior to being forced to do so. It signals to plants that the time is coming when they will have to undertake significant abatement. And it provides an opportunity for BAPEDALDA Semarang to learn about pollution and polluters in Semarang.

But these findings also show that real significant abatement of pollution in Semarang has not yet occurred. More than 60% of the plants in our sample have not invested in any pollution control. Of those that have, the mean level of expenditures as a percentage of plant sales is effectively zero. Correcting this almost certainly depends on developing more effective regulatory actions, including more systematic and reliable monitoring of emissions and a broader range of sanctions to force reluctant polluters to comply with emissions standards. Evidence from our Korean sample of manufacturing plants shows that this can work.

Appendix 4A. Survey Questionnaire Administered to Plant Managers in Semarang

1. What are the principal products of your plant?
2. Are some of your products sold using brand names, either your own or foreign brand names?
3. Do you export products?
4. Could you give a rough estimate of how much (what percent) of your total production is exported and how much is sold in Indonesia?
5. In the following, I would like to know how you assess the seriousness of various forms of pollution in Semarang. We will do so on a scale of 1 to 10 where '1' represents 'not serious at all' and 10 represents 'very serious'.

	1	5	10
Noise pollution			
Air pollution			
Water pollution (River/lake/sea)			

6. Have you heard or read about pollution in the vicinity of this location here?
7. Has your plant installed pollution control equipment?
8. When did you install (what year) pollution control equipment?
9. Is the whole plant equipped with pollution control equipment?
10. Do you service the pollution control equipment?
11. Do you have problems in servicing the pollution control equipment?
12. Over the past five years (1991–1996), what have been the annual capital costs for pollution control?
13. Over the last five years, what have been the annual operation and maintenance costs for pollution control?
14. Does your plant self monitor its emissions?
15. Does your plant report the results of self monitoring to BAPEDALDA Semarang?
16. Do you have any environmental staff?
17. Does your plant have specific quantitative goals for reducing pollution?
18. Has your plant commissioned any environmental audits?
19. In some countries, plant managers have frequent contact with neighbors in the community adjacent to their plant, and one of the topics plant managers and neighbors discuss is pollution from the plant. Have you observed or are you aware of instances where representatives (neighbors, local community leaders, or NGOs) of communities complain to plant managers in Semarang about pollution from their plants?
20. Have these representatives asked plant managers to reduce pollution from the plant?
21. Have plants entered into any kind of pollution control agreement with these representatives?
22. Have plants compensated individual neighbors for the adverse effects of pollution?

23. Have plants made payments or provided funds to increase community welfare such as providing drinking water?
24. Have your neighbors or their representatives (such as local community leaders or NGOs) come to you to complain about pollution from your plant?
25. Have these representatives asked you to reduce pollution from your plant?
26. Has your plant entered into any kind of pollution control agreement with these representatives?
27. Has your plant compensated individual neighbors for the adverse effects of pollution from your plant?
28. Has your plant made payments or provided funds to increase community welfare such as providing drinking water?
29. In some countries, buyers of a plant's output consider the plant's environmental performance before buying from a plant. Have you heard of or are you aware of other plants in Semarang where buyers made a plant's environmental performance or its emissions levels a condition that affected the buyer's purchasing decision?
30. Do you know of cases where buyers asked whether plants were in compliance with government environmental regulations?
31. Do you know of cases where buyers offered to help plants reduce emissions?
32. Have any of your buyers made your plant's environmental performance or emissions levels a condition that affected whether they bought goods produced in your plant?
33. Have your buyers asked whether your plant is in compliance with government environmental regulations?
34. Have your buyers offered to help you reduce emissions from your plant?
35. In some countries, government agencies encourage plants to reduce emissions by offering financial incentives. Has your plant received tax breaks or duty free imports for the purchase of pollution control equipment?
36. Has your plant received low interest (subsidized) loans for the purchase of pollution control equipment?
37. In some countries, government closely regulates industrial plants' environmental performance by monitoring and enforcing emissions standards. Has government monitored or inspected your plant for compliance with emissions standards for air or surface water?
38. Could you indicate when was the last time your plant was monitored or inspected?
39. How many times has government monitored emissions from your plant in the last year?
40. Have any of the following enforcement actions of the government been applied to your plant:

    Warning letter from BAPEDALDA?
    Warning letter from the Mayor?
    No warning letter?

41. How many warning letters have you received over the past twelve months from BAPEDALDA Semarang?

42. How many warning letters have you received over the past twelve months from the Mayor?
43. When (in what year) was the plant built?
44. Who owns this plant (what percent is owned by foreigners, the government, private domestic investors)?
45. What was the total number of employees in your plant in 1996?
46. What was the total value of sales (in rupiah) in 1996?

5

Globalization, Openness to Trade and Investment, Technology Transfer, and the Environment: The Cement Industry in East Asia

5.1 Introduction

Neo-liberal orthodoxy asserts the positive benefits of open trade and investment regimes and of the efficacy of market processes in shaping development outcomes. Among the benefits claimed for openness are access to capital and access to leading-edge technologies. Through trade and foreign direct investment, it is asserted, firms gain access to the best-available technology and production know-how that results in improved economic and environmental performance. To the extent that the leading-edge technologies are also less energy, materials, and pollution intensive, new investment under conditions of open trade and investment regimes can also lead to improved environmental performance (Low 1992). By this account, pollution-intensive and energy-intensive production processes are replaced by more energy and materials-efficient production, based on technologies sourced on a global basis. Over time, the increasing integration of industrializing economies into the global economy results in improved aggregate economic and environmental performance of industry.

These claims as to the benefits of openness are disputed, however, by other researchers who suggest that the impact of openness on the environmental performance of industry is largely contingent upon the incentives that exist for adopting technologies that are less polluting and less energy and materials intensive, and more generally, upon effective governance structures at the national and local scale (Chapters 2 and 3; Brandon and Ramankutty 1993; Rock 2002*a*). Under conditions of openness firms have a range of technology choices and may well choose technologies that are below international standards of environmental performance, particularly when technologies that achieve higher environmental performance are more costly or more capital intensive than older, more pollution-intensive technologies. In addition, countries with weak environmental regulations may emerge as 'pollution

havens' for pollution-intensive industries (Baumol and Oates 1988; Neumayer 2000), particularly when new foreign investment actually involves older 'dirty' technologies, as appears to have happened in some parts of the textiles and electro-plating industries (Rock 2002*a*). In this view, improved environmental performance within particular industries depends *inter alia* upon the coexistence of two conditions: access to technologies that are less energy, materials, and pollution intensive, and incentives to select these technologies (whether in the form of environmental regulation, resource pricing, or other tools of environmental policy, such as policy integration) and to adapt them to local conditions.

We approach the issue of the impact of technology flows on industrial environmental outcomes in the rapidly industrializing economies of East Asia from the theoretical and empirical perspectives of recent work on technological upgrading and within economic geography. A large body of work now exists on technological upgrading[1] and within economic geography examining the internationalization and globalization of production systems, including research on the structure of global production networks (Dicken *et al.* 2001; Henderson *et al.* 2002), on the dynamics of trade and investment, and the operation of multinational firms (Dicken 2000). The hallmark of this work is detailed empirical examination of actual firms and production networks at the regional, national, and global scale. While this work has been very influential, there has been little effort to date to extend the line of analysis to include the environmental performance of firms and the environmental impacts of economic activity. We seek to address this gap by examining a key aspect of economic globalization, namely, increasing openness to international trade and investment, and the impact of openness on the environmental performance of a particularly dirty industry, cement, in four rapidly industrializing economies in Asia—Indonesia, Malaysia, Thailand, and China.

5.2 Trade and Investment Liberalization and the Environment

Research linking trade and investment liberalization to environmental change typically distinguishes among three structural effects: scale, composition, and intensity (Reppelin-Hill 1999; Copeland and Taylor 2003). The scale effect hypothesizes that liberalization results in higher rates of economic growth (Frankel and Romer 1999), and through this growth increased use of resources and pollution. The composition effect suggests that liberalization impacts the sectoral mix of output and patterns of trade across countries. The most commonly cited example of a composition effect is that pollution-intensive industries may be attracted to countries with weak environmental regulations. The

[1] For a review of this literature, see Chapter 2.

intensity effect hypothesizes that liberalization impacts the intensity of environmental impact per unit of output (e.g. energy use per unit of production) or in some formulations the rate of adoption and diffusion of technologies that are less pollution and energy intensive. Some of the earliest research linking trade liberalization and the environment focused specifically on the composition effect. The findings of this initial work were quite mixed. Grossman and Krueger (1993), Leonard (1988), Low and Yeats (1992), and Tobey (1990) concluded there was little empirical support for the claim that the intensity of environmental regulation impacted patterns of trade, or the location of industries. There are also a small number of studies focusing specifically on the intensity effect, including research by Reppelin-Hill (1999), Wheeler and Martin (1992), and Rock (1996*a*). While Rock (1996*a*) found that the toxic intensity of GDP was greater in countries with open trade policies, both Reppelin-Hill (1999), who focused on the steel industry, and Wheeler and Martin (1992), who focused on the pulp industry, found that trade liberalization was associated with more rapid adoption and diffusion of cleaner technologies.

A second body of research focuses on the combined impact of scale, composition, and intensity effects on the environment. Because the three effects may have countervailing impacts on the environment (e.g. the scale effects of economic growth may be offset by reductions in the environmental intensity of output), these aggregated studies have the benefit of estimating the net impact on the environment of trade and investment liberalization. Cole *et al.* (1998) found that the Uruguay Trade Round increased global emissions of carbon dioxide and selected air pollutants, and Xing and Kolstad (1998) found a positive association between sulfur emissions in a country and inflows of private investment. Talukdar and Meisner (2001) found that carbon dioxide emissions per capita are lower in countries with open trade regimes and in countries with higher levels of foreign direct investment. In addition, Copeland and Taylor (2003) conclude that intensity effects of trade liberalization exceed scale and composition effects resulting in improved environmental performance, at least for one common air pollutant, SO_2.

Among the most interesting studies are those examining both the aggregate impact of trade liberalization on the environment, and the relative contribution of scale, composition, and intensity effects. Hettige *et al.* (1997) studied the impact of trade liberalization on water pollution in 12 countries, finding that scale effects led to an increase in emissions that was only partially offset by an intensity effect. The study explains the so-called 'reverse Kuznets' curve effect (in which environmental quality first declines and then improves with growth in per capita income) in terms of the relative significance of scale, composition, and intensity effects across different income levels. In a study of water pollution in China, Dean (2002) finds that whereas trade liberalization hurts the environment through composition effects, income growth is correlated with reduced environmental impact

(presumably through increased demand for improved environmental quality). Dean (2002: 841) concludes that 'the beneficial effects of trade liberalization may have outweighed the detrimental effects during this period'.

Of the three pathways through which increasing openness impacts environmental outcomes—scale effects, industry mix, and emissions intensity—because of our interest in environmental intensities and policy integration, we focus exclusively on the last category (energy and emissions intensity). Specifically, we examine the relationship between openness to trade, investment and technology, and energy and pollution intensity in the cement industry. At the same time, we examine the intersection between these processes of investment and technology choice and the strength and character of environmental regulation. We hypothesize that increasing openness to international trade, foreign investment, and foreign technology will be associated with improved environmental performance, and by the use of technologies that are less pollution and energy intensive. We further hypothesize that where firms are under more intensive regulatory pressure—either from local regulators and the community, or from customers—there will be a tendency toward improved environmental performance.

One of the limitations of virtually all of the existing studies on the impacts of increasing global economic integration on environmental performance is the dependence on estimates of environmental impact (rather than direct measurement), and upon highly aggregated data sets in which the unit of analysis is the country (Reppelin-Hill 1999; Zarsky 1999). Few studies have been conducted using plant-level data (important exceptions include Chapter 4; Pargal and Wheeler 1996; and Hettige *et al.* 1997), but none of these plant-level studies focus on measures of environmental intensities. The analysis of investment/technology decisions by firms—whether or not to invest in production processes which are less energy and pollution intensive—typically requires disaggregated analysis based on plant-level data. In addition, numerous key determinants of energy and pollution intensity of industrial production, such as the strength of regulatory enforcement, vary at the regional and local level and are difficult to measure accurately at the national scale. Our analysis involves direct measurement of emissions and of technologies-in-use at the plant scale.

5.3 The Cement Industry

There are three reasons for selecting cement production as the focus of study. First, cement is an energy-intensive and pollution-intensive industry that has been identified as a major source of both greenhouse gas emissions and air pollution. The energy consumed by the cement industry is estimated at about 2% of global primary energy consumption, or almost 5% of global industrial energy consumption (Hendriks *et al.* 1998). Because coal is typically the

primary energy source in cement production, the industry is a major emitter of CO_2 (CO_2 is also produced directly in the calcination process). The cement industry is responsible for approximately 5% of total global CO_2 emissions. In addition, the industry is a major emitter of air pollution (primarily dust, but also nitrous oxides) (US EPA 1994). Several countries have targeted the cement industry as part of their national action plans for reducing greenhouse gas emissions, and the World Business Council on Sustainable Development has launched an initiative on developing a 'sustainable' cement industry.

Second, cement production is growing rapidly, especially in industrializing and urbanizing economies. It is literally part of the building process of the massive urban-industrial transition under way in developing Asia (a transition that is predicted to add 600 million urban dwellers in China and East Asia by 2025 (WRI 1997)). Cembureau (1998) reports that over the period 1970 to 1995 cement production worldwide grew at average annual rate of 3.6%; the average annual growth rate in China over this period was 12.2%. Cement is also entangled in contemporary processes of economic globalization in interesting ways. As a bulky commodity, cement has not been, until recently, much of an export commodity. It is, however, the focus of substantial international investment and technology transfer and it is becoming more export-oriented. Much of the core kiln technology used in Asia, outside of China, is manufactured within the OECD economies. And there is a large amount of international investment in the cement industry, both in the form of new plant construction and takeovers of existing plants by international investors. The cement industry is dominated by five large multinational firms, each of which operates in upwards of 30 countries (Holcim, Lafarge, Cemex, Heidelberg Zement, and Italcementi). These large firms have bought into formerly domestically owned plants throughout the world, from North America to Latin America, Eastern Europe and Asia, including East Asia following the 1996–7 currency crises. The role of the internal management systems of these large multinationals in overseeing a global network of cement plants is another dimension of globalization of concern, a concern that is addressed in the next chapter.

Third, cement provides a useful industry within which to examine investment/technology choices. The core production process in cement manufacturing is the production of clinker from limestone and a mix of other raw material inputs. This is a kiln-based process in which raw materials are heated to temperatures in excess of 1,000 degrees centigrade. Currently there are a variety of discrete kiln-based process technologies available—ranging from older mechanical shaft kilns using 'wet' processes to highly advanced dry rotary kilns with pre-heaters. These kiln technologies vary in their fuel intensity by a factor of three with highly efficient kilns achieving an energy intensity of approximately 750 kilocalories per kilogram of clinker produced. Because there are discrete technology choices with significant environmental consequences to be made when constructing a cement kiln,

the impact of technology choices on environmental performance should be directly visible. In the case of air pollution, there is a discrete set of largely end-of-pipe pollution controls, such as bag filters and electrostatic precipitators, which can be used to reduce dust emissions. Unlike improvements in energy efficiency, which typically yield significant cost returns and a pay-off on upfront capital investment within as little as three to four years, end-of-pipe technologies for dust reduction are largely add-on costs for firms.

We have selected four countries among the East Asian newly industrializing economies from which to obtain data, namely, China, Indonesia, Thailand, and Malaysia. These countries were selected on the basis of several criteria. First, all are major cement producers. China, with cement production in 1999 estimated at 520 million metric tons, is responsible for approximately one-third of global cement production (Global Cement Information 2000). Thailand, with output in 1999 of approximately 34 million metric tons, is the world's ninth largest producer of cement, and Indonesia is the fourteenth largest producer (approximately 25 million tons). Malaysia in 1999 produced approximately 11 million metric tons of cement. Second, these countries are illustrative of newly industrializing economies that are pursuing development policies focused on export-led industrial growth and increasing integration into the global economy.

5.4 Research Design and Empirical Analysis

The plant/kiln-level data collected for study are based on a written survey questionnaire administered by local research partners at cement plants in four East Asian countries (China, Indonesia, Malaysia, and Thailand). The survey[2] was 10 pages in length and comprised four principal categories of questions: measures of environmental performance—*ENERGY*—the energy intensity (kilocalories of energy per kilogram of clinker) and *POLLUTION*—pollution intensity (grams of total suspended particulates per ton of clinker)—of clinker production in a plant's most recently constructed and operating kiln, along with measures of technology in use (see below), measures of integration into the global economy (see below), and measures of regulatory practice (see below). While cement manufacture involves several other production stages (e.g. materials preparation and grinding), we focus on energy intensity in the core kiln-based process. Where a cement plant operates multiple kilns, the plant was asked to provide data on the kiln most recently brought into operation.

With respect to technology in use, we collected data on the age of each firm's most recently constructed and operating kiln (*KILNAGE* = number of

[2] A shortened version of the survey instrument appears as Appendix 5A at the end of this chapter.

years the kiln has been operating), the capacity (and actual production) of this kiln in the most recent year (*CLINKER* = tons of clinker per year), and the technology used for manufacturing clinker in this kiln (*KILNTECH*).[3] With respect to integration into the global economy, we asked whether kiln technologies in use were imported from the OECD (*KILNIMPORTED* = 1 if the kiln was imported from the OECD and *KILNIMPORTED* = 0 otherwise), whether pollution control equipment (*PCE* = electrostatic precipitators and bag filters) to limit the emission of particulates was imported from the OECD (*PCEIMPORTED* = 1 if *PCE* was imported from the OECD and *PCEIMPORTED* = 0 otherwise), whether the plant was a joint venture with an OECD multinational (*JV* = 1 if the plant was a joint venture with an OECD multinational and *JV* = 0 otherwise), and the percentage of plant output that was exported (*EXPORT*). Because three of our kiln technology variables (*KILNTECH*, *PCEIMPORTED*, and *KILNIMPORTED*) were highly correlated,[4] we created a composite kiln/pollution control technology variable, *MODKILNPCEIMP*, where *MODKILNPCEIMP* = 1 if a kiln and pollution control equipment were imported from the OECD and kiln technology consisted of a modern dry rotary kiln with either a pre-heater or a pre-calciner and *MODKILNPCEIMP* = 0 otherwise).

With respect to environmental regulation, because existing research (Chapter 4; Pargal and Wheeler 1996) suggests that regulatory pressure, community pressure, and buyer pressure exert independent influence on the pollution control behavior of manufacturing plants in Asia, we collected data on both direct (the frequency of inspections of plants by environmental regulators—*INSPECT* = the number of inspections per year) and indirect measures of regulatory approach (whether the local community had complained about emissions (*COMPLAINT* = 1 if the local community had complained and *COMPLAINT* = 0 otherwise), and whether buyers asked about emissions compliance—*BUYERSASKCOMPLY* = 1 if buyers asked if the firm was in compliance with local emissions standards and *BUYERSASKCOMPLY* = 0 otherwise).

Our survey focused on medium and large-sized cement manufacturing plants (plants with an annual output of greater than 150,000 metric tons of clinker).[5] In Thailand there are approximately 20 cement plants with

[3] Kiln technologies included vertical mechanical shaft kilns (mostly used in China), wet rotary kilns, short wet rotary kilns, short dry rotary kilns, short dry rotary kilns with pre-heaters, and short dry rotary kilns with pre-calciners.

[4] The correlation between *KILNIMPORTED* and *PCEIMPORTED* = 0.97, the correlation between *KILNIMPORTED* and *KILNTECH* = 0.68 and the correlation between *PCEIMPORTED* and *KILNTECH* = 0.71. These correlations caused significant multicollinearity problems.

[5] China, in particular, has a large number of very small cement plants, some with annual output of as small as 20,000 metric tons, and many of which are highly polluting. In most cases, however, these small cement plants are economically uncompetitive and have been designated for closure by provincial governments.

production in excess of 150,000 metric tons, and there are approximately 15 such cement plants in Indonesia and in Malaysia. In China, survey data were collected in three provinces, each of which had a large number of cement plants with output over 150,000 metric tons.[6] In the case of Indonesia, Malaysia, and Thailand, all cement plants with a production capacity of over 150,000 metric tons were invited to complete the survey instrument. In each of these countries, the survey was administered in cooperation with a local research institute. In China, the survey was administered to a random sample of 75 cement plants in five areas in three provinces. The survey was administered in cooperation with China's State Environmental Protection Administration (SEPA). In all cases the survey was translated into the local language and submitted to the cement firm following initial contact by our research partners.

Because of the support provided by SEPA, we obtained essentially a 100% return rate on the survey administered in China. Two of the 75 sample cement plants in China were not involved in cement production, providing a final sample of 73 completed questionnaires in China. Five of 15 cement plants in Malaysia returned completed questionnaires, as did 9 of 20 plants in Thailand, and 6 of 15 cement plants in Indonesia. In total, survey data was obtained from 93 cement plants in the four countries, though not all sample plants completed all of the survey questions.[7] Table 5.1 provides data on sample means, standard deviations, and maximum and minimum values for all of our variables.

Several characteristics of our sample deserve note. To begin with, the sample plants are quite large as the mean value of clinker production is 884,392 metric tons with a range from 180,000 metric tons to 10,590,000 metric tons. As we later learned (see Chapter 6) a number of the largest and most modern cement kilns in the world are located in East Asia. The average kiln is relatively new at only 8.79 years old with a range from 7 years old to 30 years old. About a quarter of the kilns in our sample have been imported from the OECD, have both pre-calciners and pre-heaters, and have imported pollution control equipment (both electrostatic precipitators and bag filters). Roughly 7% of the output in our sample is exported with a range from no exports to all output being exported. Roughly 25% of the plants in our sample are part of a joint venture with OECD multinationals. Energy use averages 928.3 kilocalories per kilogram of clinker with a relatively large range from 710 (international best-practice level) to 1,368 kilocalories per kilogram of clinker. Emission of total suspended particulates averages 0.971 kilograms per ton of clinker with an even larger range from 0.01 kilograms

[6] In the case of Jiangsu Province, for example, there are approximately 90 cement plants with output in 2001 of more 150,000 metric tons of clinker.

[7] A comparison of the characteristics of participating and non-participating plants by size and ownership status (private or government owned) did not reveal any significant self-selection bias.

TABLE 5.1. Descriptive statistics of surveyed cement plants

Variable	Mean	Standard deviation	Maximum	Minimum
ENERGY	928.30	168.06	1,368	710
POLLUTION	0.971	1.68	7.5	0.01
CLINKER	0.844	1.64	10.59	0.018
KILNAGE	8.79	6.77	30	0
MODKILNPCEIMP	0.243	0.43	1.0	0
EXPORT	7.71	19.16	100	0
JV	0.258	0.44	1	0
INSPECT	7.74	6.34	36	0
BUYERSASKCOMPLY	0.769	0.559	1	0
COMPLAINT	0.64	0.48	1	0

Source: Survey data.

per ton to 7.5 kilograms per ton of clinker. On average our sample plants are inspected by environmental regulators 7.74 times per year with a range from no inspections to 36 inspections per year. Finally, 77% of the plants report that buyers ask them if they are in compliance with emissions standards and 64% report that residents in their communities have complained about their emissions.

We tested our hypotheses linking kiln-level environmental outcomes—*ENERGY* or the energy intensity of a kiln (kilocalories of energy per kilogram of clinker) and *POLLUTION*, the pollution intensity of a kiln (grams of particulate emissions per kilogram of clinker)—to a bundle of kiln technology variables, openness, and regulatory pressure by estimating two ordinary least squares regression equations using White's heteroskedasticity-consistent standard errors and covariance to correct for heteroskedasticity. As noted above, because three of our kiln technology variables (*KILNTECH*, *PCEIMPORTED*, and *KILNIMPORTED*) are highly correlated, we relied on a composite kiln/pollution control technology variable, *MODKILNPCEIMP* as a measure of a plant's openness to modern OECD kiln and pollution control technology. Lest anyone fear that our results are driven by one or two outlying kilns with these characteristics, it is important to note that 20 out of 93—more than 20% of the plants in our sample—had values of 1 for the variable *MODKILNPCEIMP*. These plants were operating large,[8] state-of-the-art,[9] imported dry rotary kilns with pre-heaters and/or pre-calciners. All of these plants were also using imported pollution control equipment (electrostatic precipitators or ESPs) and 40% combined ESPs with bag-house filters.

[8] The average kiln produced 2.9 million tons of clinker per year, while several produced more than 10 million tons of clinker per year.

[9] The average kiln was only 7.5 years old.

The OLS regression equation estimated for energy intensity (*ENERGY*) is

$$\text{Log}\ (ENERGY)_i = a_0 + a_1\ \text{Log}\ (CLINKER)_i + a_2\ \text{Log}\ (KILNAGE)_i + a_3\ MODKILNPCEIMP_i + a_4\ EXPORT_i + a_5\ JV_i + \varepsilon_i$$

where i refers to plant i, ε_i is the standard error of the regression for plant i, and the other variables are as described above. The OLS equation estimated for pollution intensity (*POLLUTION*) is

$$\text{Log}\ (POLLUTION)_i = b_0 + b_1\ \text{Log}\ (CLINKER)_i + b_2\ \text{Log}\ (KILNAGE)_i + b_3\ MODKILNPCEIMP_i + b_4\ EXPORT_i + b_5\ JV_i + b_6\ INSPECT_i + b_7\ BUYERSASKCOMPLY_i + b_8\ COMPLAINT_i + \varepsilon_i$$

Because kiln size (*CLINKER*) might be endogenous in both equations, we tested for endogeneity by using a version of the Hausman test proposed by Davidson and MacKinnon (1993: 237–42).[10] Results indicated that we can safely reject the null hypothesis of endogeniety.

The results of the statistical analysis are shown in Table 5.2 for energy intensity (*ENERGY*) and Table 5.3 for pollution intensity (*POLLUTION*). In both equations, missing data on one or more variables reduced the

TABLE 5.2. OLS regression equation on *ENERGY*

Independent variable	Regression coefficient	Standard error	t-statistic
Constant	6.81		
Log (*CLINKER*)	0.014	0.017	0.86
Log (*KILNAGE*)	0.052	0.017	2.99***
MODKILNPCEIMP	−0.256	0.045	−5.64***
EXPORT	−0.0009	0.0004	−2.14**
JV	−0.008	0.036	−0.23
Adjusted R^2	0.48		
Equation F statistic	12.26***		

Notes: Estimation is with White's heteroskedasticity-consistent standard errors and covariance. *** indicates statistical significance at the 0.01 level. ** indicates statistical significance at the 0.05 level.

[10] This test requires estimating an artificial OLS regression equation on the variable suspected of being endogenous (Log (*CLINKER*)) on all the exogenous variables in our OLS *ENERGY* and *POLLUTION* equations plus one or more instrumental variables that are correlated with our suspected endogenous variables, but not with the error term in our basic OLS equations. Thus for both our *ENERGY* and *POLLUTION* OLS equations, we regressed Log (*CLINKER*) on the exogenous variables in each OLS equation and two instrumental variables (the number of kilns a plant has and whether or not a plant was totally government owned). The residual from each artificial equation was then added as independent regressor in each original OLS equation. In both instances, resulting t test statistics on the coefficients on the first-stage residuals suggested that those coefficients were not significantly different from zero. This led us to reject the null hypothesis that kiln size (*CLINKER*) was endogenous in either regression equation.

number of cases included in the analysis. Both equations were fully significant at the 0.01 level of confidence. In the energy intensity equation in Table 5.2, three of our independent variables—kiln age, share of output exported, and our composite kiln technology variable (*MODKILNPCEIMP*)—are statistically significant with the expected sign and taken together the independent variables account for nearly one-half of the variation in the energy intensity of our sample kilns. For the pollution intensity equation in Table 5.3, these same variables plus two of our regulatory variables (*INSPECT* and *BUYERSASKCOMPLY*) are statistically significant with the expected sign and taken together the independent variables in this equation account for roughly 40% of the variation in pollution intensity in our sample of kilns. Both equations offer powerful support for our hypothesis that openness to trade (*EXPORT*) and OECD kiln and pollution control technology (*MODKILNPCEIMP*) exert significant influence on the energy and pollution intensity of cement kilns in Asia. In addition, the *POLLUTION* equation offers testimony to the impact of our regulatory variables on plant-level emissions.

A better sense of the impact of openness as measured by trade (*EXPORT*), foreign investment (*JV*), and imported technology (*MODKILNPCEIMP*) on energy intensity in our sample of kilns can be gained by comparing the estimated values of *ENERGY* at the mean values of the independent variables in the estimated equations in Table 5.2 with the estimated values of *ENERGY* at a one standard deviation 'improvement' in these openness variables. A one standard deviation improvement in openness

TABLE 5.3. OLS regression equation on *POLLUTION*

Independent variable	Regression coefficient	Standard error	t-statistic
Constant	−0.41		
Log (*CLINKER*)	0.198	0.138	1.43
Log (*KILNAGE*)	0.516	0.155	3.32***
MODKILNPCEIMP	−1.65	0.401	−4.12***
EXPORT	−0.017	0.007	−2.39**
JV	−0.22	0.284	−0.77
INSPECT	−0.039	0.012	−3.00***
BUYERSASKCOMPLY	−0.445	0.241	−1.84*
COMPLAINT	−0.013	0.284	−0.047
Adjusted R^2	0.38		
Equation F statistic	5.44***		

Notes: Estimation is with White's heteroskedasticity-consistent standard errors and covariance. *** indicates statistical significance at the 0.01 level. ** indicates statistical significance at the 0.05 level. * indicates statistical significance at the 0.10 level.

reduces energy intensity by roughly 15% (from 943 kilocalories per kilogram of clinker to 812 kilocalories per kilogram of clinker). If, in addition, openness is combined with a one standard deviation decline in the age of a kiln, energy intensity falls by another 6% (from 812 kilocalories per kilogram of clinker to 764 kilocalories per kilogram of clinker). This is powerful evidence of a relatively large (21% reduction in *ENERGY*) technique effect and it is testimony to the impact of openness to trade, foreign investment, and technology trade on energy intensity. Because our East Asian countries of study have been open to trade, foreign investment, and foreign technology for some time, the effect of openness gained from these calculations are most probably understated. To get a truer sense of the gains from openness, we compared the mean values of *ENERGY* for plants in our sample that did not export (*EXPORT* = 0), were not joint venture partners with OECD multinationals (*JV* = 0), and which did not import their technology from the OECD economies (*MODKILNPCEIMP* = 0) with those that imported their kilns and pollution control equipment from the OECD, were joint venture partners with OECD multinationals, and did export. Calculated this way, openness, by itself, reduces energy intensity by nearly 25% (755 kilocalories of energy per kilogram of clinker versus 992 kilocalories of energy per kilogram of clinker). Yet another measure of the effect of openness on energy intensity can be gained by comparing *ENERGY* for the most efficient plant in our sample to the least efficient plant in our sample. Not surprisingly, energy intensity in the best-performing kiln (710 kilocalories per kilogram of clinker) belongs to a plant with a kiln recently imported (the kiln is 6 years old) from the OECD and imported pollution control equipment. This plant exports 30% of its production and it is a joint venture with an OECD multinational. Energy intensity in the poorest performing kiln (1,368 kilocalories per kilogram of clinker) is nearly two times higher (1.93 times) than the best-performing kiln. Not surprisingly, this kiln is relatively old (11 years old), was produced locally, and it is wholly owned by a local firm that sells all of its output locally. Taken together, these findings suggest that the benefits to *ENERGY* from openness to trade, foreign investment, and foreign technology in a sample of kilns taken from these four East Asian economies that have been open to trade, foreign investment, and foreign technology for a substantial period of time range from a low of 15% (a saving of 131 kilocalories per kilogram of clinker) to a high of 93% (658 kilocalories per kilogram of clinker).

The impact of openness to trade (*EXPORT*), foreign investment (*JV*), and foreign technology (*MODKILNPCEIMP*) on *POLLUTION*, or pollution intensity, is even more dramatic. At the mean values of all the independent variables in the estimated equation in Table 5.3, *POLLUTION* averages 0.574 kilograms per ton of clinker, but a one standard deviation improvement in the openness variables alone causes pollution intensity to drop by 70% to 0.168 kilograms per ton of clinker. If a one standard deviation improvement

in the openness variables is combined with a one standard deviation improvement in the age of a kiln, pollution intensity drops to 0.083 kilograms per ton of clinker, more than 85% lower than the mean prediction. A one standard deviation improvement in all three regulatory variables (*INSPECT*, *BUYERS-ASKCOMPLY*, and *COMPLAINT*) exerts an equally powerful impact as pollution intensity drops from 0.574 kilograms per ton of clinker in the base case to 0.114 kilograms per ton of clinker (or 81%) as regulatory pressure on plants rise. When openness to trade, investment, and technology is combined with regulatory pressure and relatively new kilns, pollution falls an astounding 92% to 0.05 kilograms per ton of clinker. This is powerful evidence of the joint impact of openness and regulatory pressure on the pollution intensity in our sample of kilns. But in some sense, these findings are not particularly surprising as the cleanest kiln in our sample has a pollution intensity of only 0.01 kilograms per ton of clinker while the dirtiest plant in the sample has a pollution intensity that is 750 times larger at 7.5 kilograms per ton of clinker. Not surprisingly, this dirty kiln was produced locally, is very old (26 years), and is wholly owned by a local firm that does not export, while the cleanest kiln is wholly owned by a large local firm that does not export, this kiln is brand new (less than 1 year old), and both the technology and pollution control equipment have been sourced from the OECD.

The results of our analysis provide substantial support for the hypothesis that openness to trade, foreign investment, and foreign technology is associated with enhanced environmental performance among our sample cement plants. As shown in Tables 5.2 and 5.3, whether the kiln and pollution control equipment used by a cement plant is imported or not is an important determinant of the energy intensity and pollution intensity of cement production. Plants with imported kilns use substantially less energy to produce a ton of clinker. In fact, plants with modern kilns imported from the OECD, with pre-heaters and pre-calciners, use 25% less energy (764 kilocalories per kilogram of clinker versus 994 kilocalories per kilogram of clinker) to produce a kilogram of clinker. Within the trade-oriented economies of Indonesia, Malaysia, and Thailand, the tendency over the past two decades has been to import advanced kiln equipment from Japanese, European, and North American suppliers. Many older cement plants in China, by contrast, use less energy efficient kiln technologies manufactured by domestic firms. Some of the more recently constructed cement plants in China, especially those involving joint ventures with foreign firms, use imported kiln technologies. Among the organizational variables included in the analysis, the age of the kiln is a key determinant of the energy intensity of production. As anticipated, older kilns tend to use more energy to produce a ton of clinker. A similar pattern of results is observed for pollution intensity. As shown in Table 5.3, plants using imported kilns with imported pollution control equipment tend to have lower levels of particulate emissions, as do plants with newer kilns.

The results of our analysis also support the hypothesized impact of regulatory pressure on pollution intensity. Environmental regulation apparently operates both directly through the impact of environmental regulatory inspections of plants, and indirectly through the pressure that customers place on cement plants to comply with local and national environmental regulations. Plants whose customers ask about environmental regulatory compliance tend to have lower particulate emissions.

What emerges in this analysis is a picture of an industry that bears the imprint of the particular way in which cement production has developed within the context of the rise of the newly industrializing economies of East Asia starting in the 1960s. Both the timing of the urban-industrial transition within the region, and the mode of incorporation into the global economy, impacted the economic and environmental performance of the industry. As demand for cement skyrocketed in the context of the urban-industrial transition within East Asia NIEs, domestic firms emerged as the largest suppliers for domestic markets. Most of the major cement firms in Thailand, Malaysia, and Indonesia were domestically owned through the late 1980s, and almost all of the larger cement plants in China were government enterprises. By contrast, most of the major suppliers of equipment to cement firms were based in OECD countries, and this was especially the case for advanced kiln technologies. In the case of Malaysia, Thailand, and Indonesia many domestically owned cement plants sourced their core kiln technology and associated pollution control equipment from these leading equipment suppliers located in the OECD countries. This reflected the well-documented strategy of firms in the East Asian newly industrializing economies to scan the globe for technologies that were economically competitive.[11] Because energy costs are a major factor in the overall production costs of cement plants, the kiln technology sourced internationally tended to be both economically competitive and energy efficient. The older kiln technologies available from local suppliers, particularly in China, tended to be less energy efficient and more pollution intensive. As a consequence, the overall environmental performance of cement plants in East Asia is closely tied to the timing and pattern of global sourcing of kiln technology. This is most clearly seen in China where cement plants constructed prior to the 1990s were likely to be based on older, inefficient, kiln technologies sourced from other government firms.

As shown in our statistical analysis, both the age of the kiln and whether the kiln technology is imported are key determinants of the energy intensity of cement production. Interestingly this also holds for the pollution intensity of production, though this may be related in part to the bundling of pollution control equipment with core kiln technology in the sourcing of plant equipment. Our analysis shows that in the case of pollution intensity,

[11] The next chapter provides a detailed case study of how this process played out in one very large and domestically owned cement firm in Thailand.

regulatory pressure also makes a difference. This regulatory pressure is applied by traditional regulatory inspections, but also through the influence of customer-driven supply chains.

5.5 Conclusions

Our goal in this chapter is to bring the differing theoretical and empirical perspectives of the impact of globalization on environmental outcomes to bear on the energy and pollution intensity of actual cement plants, plants in a particularly fast-growing and dirty industry in the East Asian NIEs. We followed a tradition within economic geography of studying globalization 'on the ground' through detailed analysis of industrial sectors and production networks in the hope of providing valuable insights into the ways in which intensified international flows of capital, information, and technology are impacting the environmental performance of firms. Our focus is on one aspect of the links between trade, investment, and the environment, namely, the intensity of environmental impact per unit of output. It is important to note in this regard that in rapidly industrializing economies in East Asia, incremental improvements in energy and pollution intensity are often overridden by the scale effects of increased production. Even as energy use per ton of cement produced declines, rapid growth in total cement production will result in increased total energy use, and increases in attendant greenhouse gas emissions.

Up until the early 1990s, the economic geography of the cement industry in East Asia was relatively straightforward. Cement plants in China were predominantly government-owned enterprises that sourced equipment and technical support domestically. Elsewhere in East Asia, the majority of larger cement plants were domestically owned, but sourced key technologies internationally. This tendency to source key process technology internationally was the primary pathway through which integration into the global economy impacted the environmental performance of cement firms in the region. This is of course a quite traditional supply relation that is a far cry from the intensive flows of capital and foreign investment that are at the core of current debates over economic globalization. When compared with foreign direct investment-dominated sectors, such as electronics or automobile assembly, cement production in East Asia remained thoroughly constrained in its global connections.

This all began to change during the 1990s, and most dramatically after the East Asian financial and currency crises of the late 1990s. During the 1980s, the cement industry worldwide entered a phase of consolidation. The larger cement firms in Europe, including the French firm Lafarge, Heidelberg Cement in Germany, and the British firm Blue Circle, began to buy up existing cement plants and cement firms around the world, incrementally

acquiring plants in North America, Eastern Europe, and Latin America during the 1980s and early 1990s. Typically, consolidation took the form of acquisition of existing cement plants, rather than the construction of new cement plants. As one industry analyst argued, for all the image of dust, bulk material, and heat, cement construction was fundamentally a 'knowledge industry' and as such provided multiple opportunities for large firms to achieve economies of scale and scope in capital financing, management systems, and technological learning (*The Economist* June 19, 1999). East Asia was viewed by these increasingly large building materials conglomerates as a key potential market for expansion. With the opening up of China to increased foreign investment during the 1990s, these international building materials firms, along with Japanese and other competitors, began to enter into joint ventures in the cement industry in China. In many cases these joint ventures involved partial ownership in existing formerly government-owned enterprises. In the case of China, international investment was often associated with substantial improvements in the economic and environmental performance of cement plants. Where new kilns were brought on line using advanced imported kiln technology and imported pollution control equipment, the result was a substantial reduction in the energy and pollution intensity of production.

Through the mid-1990s domestically owned cement plants in Indonesia, Thailand, and Malaysia remained elusive targets for OECD-based conglomerates. Because these plants were in most cases relatively new, and built using globally sourced advanced kiln technology, they tended to be relatively low cost producers and in many cases were amongst the most energy-efficient cement plants in the world.[12] The East Asian financial and currency crises of 1997–8 created severe debt problems for many of these firms, however, and these debt problems were soon followed by a collapse in sales revenue attendant on the slowdown of the regional economy. As a consequence, large building conglomerates such as Lafarge and Holcim were able to acquire the assets of numerous cement plants in East Asia. By the end of the decade of the 1990s, the cement industry in East Asia was becoming more traditionally 'globalized' in the sense of substantial foreign direct investment in the industry, and of the operation of the plants within firm-wide corporate management systems. By one estimate, the share of cement production capacity in East Asia (excluding China) controlled by multinationals increased from 20% in the mid-1990s to 60% at the end of the decade (*The Economist* June 19, 1999).

The implications of this latest phase of globalization of the industry for environmental performance remain, however, quite complicated. We had initially supposed that the acquisition of cement plants in the East Asian

[12] The case study in the next chapter of one large domestic firm in Thailand documents this in some detail.

NIEs would be accompanied by further rounds of environmental improvement, driven by the environmental management systems of the parent international firm. In several areas of environmental performance (see Chapter 6) this does seem to be the case. European firms, in particular, have strength in the application of standardized management practices (such as computerized performance tracking, and continuous monitoring of energy and materials flows and emissions), and most especially in use of recycled and waste materials as an alternative source of fuel. But in other cases the flow of information, technology, and best practice has been from the acquired plant in Asia to the parent firm and to other plants within the corporate network (see Chapter 6). As in other industries, leading cement firms in East Asia engaged in an ongoing and intensive process of technological learning and upgrading that included modifying and improving technologies initially acquired from OECD suppliers. The resultant geography of knowledge flows is thus far from simple. But the overall consequence is likely to be an enhancement in the environmental performance of cement plants as measured by energy and pollution intensity. The crucial question from an environmental standpoint is whether these technological and organizational improvements can offset the scale effects of economic growth. Such an outcome is likely to depend upon broader structural transformations in patterns of production and consumption of building materials.

Our primary goal in this research was to extend recent theoretical and empirical research within economics and economic geography beyond the longstanding focus on economic competitiveness to consider issues of environmental performance of the firm. In doing so, we have begun to identify several dimensions of contemporary processes of economic globalization of more general relevance to economics and economic geography. Perhaps of greatest significance is the growing influence of internal corporate management structures in shaping economic and environmental performance across a global network of production facilities.[13] Within the large business conglomerates that now dominate cement production worldwide (outside of China), corporate management practice is now shaping a myriad of critical business decisions, from which qualified suppliers to use, to what technology to employ, how to measure performance, and what standards of performance to adhere to. Interestingly, this corporate management practice has a complicated organization and geography that is a far cry from the traditional core–satellite model that dominated earlier phases of economic globalization. Within contemporary global production networks, knowledge and learning takes place throughout the corporation, originating in different places, and flowing in multiple directions. Conditions within one production region can have broad consequences throughout a firm's production

[13] For discussion of the role of corporate environmental standards on environmental outcomes see Chapter 8.

network, as when environmental regulatory standards in one part of the world are adopted by firms as a global production standard (even in the absence of international regulatory standards). At the same time, convergence around internal management standards, as when firms limit the choice of suppliers to a single global list of qualified suppliers, constrains the opportunities for participation in production networks. The tension between homogenization and differentiation within global corporate production networks, and the influence on development and environment outcomes, is, as we demonstrate and argue in Chapter 8, a fruitful area for further work.

Appendix 5A. Abbreviated Cement Survey Questionnaire

A. Plant Operations

1. What is the name and title of the person completing this questionnaire?
   Name: ______________________________________
   Title: ______________________________________
2. What is the name and address of this cement plant?
   Name: ______________________________________
   Address: ___________________________________
3. What is the total output of this plant in 2000, measured in metric tons of clinker?
   Metric tons of clinker produced in 2000: _____

B. Openness

4. Is your plant a joint venture with a foreign firm?
   Yes: ___
   No: ___
5. What percent of your output is exported?
   Percent of output exported: _____

C. Kilns and Kiln Technologies at Your Plant

6. How many kilns do you have at this plant?
   Number of kilns: _____
7. In what year did each kiln become operational?
   Year kiln became operational
   Kiln Number 1:______
   Kiln Number 2: _____
   Kiln Number 3: _____
8. Which of the following best describes the kiln process technology for the last kiln to become operational at this plant?
   Mechanical kiln shaft: _____
   Wet rotary kiln: _____
   Short wet rotary kiln: _____
   Short dry rotary kiln: _____
   Short dry rotary kiln with multi-stage pre-heaters: _____
9. Is the kiln technology for this kiln produced locally or imported?
   Kiln technology is produced locally: ___
   Kiln technology is imported from the OECD: ___
10. Do you have electrostatic precipitators installed at this kiln?
    Yes: ____
    No: _____
11. Are your electrostatic precipitators installed on this kiln produced locally or imported?
    Produced locally: ___
    Imported from the OECD: ___

12. Do you have bag filters installed at your most recently installed kiln?
 Yes: _____
 No: _____
13. Are the bag filters installed at this kiln produced locally or imported?
 Produced locally: ___
 Imported from the OECD: ___
14. What is the total fuel energy used in your most recently installed cement kiln in 2000?
 Total fuel energy used in your most recently installed kiln in one year (2000) measured in kilo-calories: _____
 Total fuel energy used in one year (2000) in your most recently installed kiln measured in kilo-calories per kilogram of clinker produced in this kiln in 2000: _____
15. What was the level of particulate (dirt and dust) emissions at your most recently installed kiln in 2000, measured in kilograms?
 Kilograms of particulate emissions in your most recently installed kiln in 2000: _____
 Kilograms of particulate emissions in your most recently installed kiln in 2000 per metric ton of clinker produced: _____

D. Environmental Regulation

16. How many times did environmental regulators inspect your plant last year (2000):
 They never inspected my plant: _____
 They inspected my plant _____ times in 2000.
17. Have residents of the community where your plant is located ever complained about air pollution from your plant?
 Residents have never complained about air pollution from my plant: _____
 Residents have rarely complained about air pollution from my plant: _____
 Residents have sometimes complained about air pollution from my plant: _____
 Residents have regularly complained about air pollution from my plant: _____
18. Have buyers of your cement plant ever asked if your plant is in compliance with emissions standards?
 Yes: ___
 No: ___

6

Win–Win Environmental Intensity or Technique Effects and Technological Learning: Evidence from Siam City Cement

6.1 Introduction

As we demonstrated in Chapter 5 and as a small, but rapidly growing, body of research suggests, developing countries appear to be able to achieve win–win technique effects—reductions in the energy, materials, water, and pollution intensities of industrial production—simply by opening their economies to trade, foreign investment, and foreign technology (Copeland and Taylor 2003; Dean 2002; Reppelin-Hill 1999; Hettige *et al.* 1997; Wheeler and Martin 1992; Birdsall and Wheeler 1992; Lucas *et al.* 1992).[1] While extremely promising, none of this body of work allows for in-depth analysis of the strategies and processes used by individual firms that import newer, more efficient, and cleaner technologies to reduce environmental intensities. In effect, this literature tells us much about win–win outcomes, but it says little about how these outcomes are achieved.

If the import, adoption, and use of technologies that reduce environmental intensities were a simple and relatively costless process, this would not be a major source of concern. But, as we demonstrated in Chapter 2, there is a large literature suggesting that, on the contrary, technological learning and upgrading is a complex, difficult, and lengthy process, often marked by failure, that requires firms to make heavy investments in learning and upgrading (Amsden 2003, 1989; Bell and Pavitt 1992; Dahlman *et al.* 1987; Hobday 1997; Kim 1997; Lall 1992; Nelson 1993; Kim and Nelson 2001; Wade 1990; and UNIDO 2002*b*) before they can reap the economic and environmental gains associated with shifts to more efficient technologies.

[1] Copeland and Taylor (2003) refer to this effect as a technique effect while others refer to it as an intensity effect. The technique effect needs to be distinguished from both the scale and composition effects of open trade and investment policies. The scale effect is associated with increases in pollution attending increases in the scale of production following an increase in openness while the composition effect measures changes in pollution attending changes in the composition of output attributable to an increase in openness.

The core research question to be addressed in this chapter then is the importance of firm-level learning for achieving the win–win technique effects—improvements in environmental intensities associated with the import and adoption of energy and pollution-efficient technologies. Because firm-level learning is industry specific, path dependent, and influenced by the openness of an economy to trade, investment, and foreign technology, we focus on the learning effects of intensities reduction in one firm, Siam City Cement Public Company Ltd. (SCCC),[2] in one particularly 'dirty'[3] and rapidly expanding developing country industry (cement)[4] that is undergoing substantial technological modernization,[5] global consolidation, and greening,[6] in an economy, Thailand, that has historically been very open to trade, investment, and foreign technology (Pongpaichit 1980). We do so by describing the technological trajectory of SCCC from its founding in the early 1970s through its recent joint venture relationship with a Swiss multinational cement conglomerate—Holcim Ltd.[7] Before turning to our study of

[2] We chose to study SCCC because it is the world's thirteenth largest producer of cement, home of two of the world's most modern and largest cement kilns, and it is a recent joint venture partner with Holcim, a multinational cement conglomerate with an enviable environmental sustainability program (Holcim 2002). The primary material for this case study was obtained in multiple in-depth interviews over several months with Mr Somboon Phuvoravan, senior vice president for cement manufacture at Siam City Cement's production facilities some 129 kilometers northeast of Bangkok along Thailand's Freedom Highway. We are deeply indebted to Mr Somboon for the time, energy, and insights he provided during our visits with him at SCCC. Mr Somboon has a BA in mechanical engineering from Chulalongkorn University and an MBA from Thammasat University. He is one of 12 members on SCCC's Board of Directors. He is one of seven members of the Board's Executive Committee. And he is one of 11 members on the Holcim Group's Technical Council (TC). He has been working at SCCC since 1976. Unless otherwise noted, all subsequent information and data come from these interviews.

[3] In addition to the environmental problems associated with the mining of limestone, the major raw material used in the manufacture of cement, cement manufacture results in significant amounts of dust (total suspended particulates and PM10), SO_2, NO_x, dioxin, and CO_2 (van Oss and Padovani 2003: 95–109)

[4] Between 1996 and 2000, Asia accounted for nearly 60% of global cement production (van Oss and Padovani 2003: 107).

[5] The energy efficiency (and hence likely CO_2 emissions) from cement kilns in the US varies from a high of 6.17 million Btu per ton of clinker for small wet kilns to 5.85 million Btu per ton of clinker for all old plants to a low of 4.08 Btu per ton of clinker for all new plants and 3.82 million Btu per ton of clinker for new large dry rotary kilns with pre-heaters and pre-calciners (van Oss and Padovani 2002: 103). In addition, installation of modern electrostatic precipitators and/or bag-house filters can result in the capture of 99% or more of the particulates (dust) associated with the manufacture of clinker in a kiln (van Oss and Padovani 2003: 96).

[6] A number of the large multinational cement conglomerates that increasingly dominate the global cement industry have aggressive emissions reductions programs, including reductions in CO_2 emissions, and equally aggressive alternative fuel and raw materials programs designed to reduce the environmental footprint of cement manufacture (van Oss and Padovani 2003: 107–14; Holcim 2002).

[7] While roughly a half dozen multinational cement conglomerates have been buying up cement plants around the world, acquisitions in East Asia did not accelerate until the East

SCCC, we reiterate what is known about technological capabilities building in developing country firms and how developing country policies affect the willingness of firms to make investments in building their technological capabilities. Insights from this literature are then used to focus our case study on technological and environmental capabilities building in SCCC and the effects of those investments in learning on environmental intensities.

6.2 Technological Capabilities Building

As we demonstrated in Chapter 2, it is now widely recognized that building technological capabilities in indigenous industrial firms in developing economies so they can produce efficiently, thrive and grow, provide numerous good paying jobs, link and export to and compete in the global economy requires conscious effort by both individual firms and government (Dahlman *et al*. 1987). For their part, firms must commit substantial resources to a long-term, incremental, and cumulative, but difficult, uncertain, and risky effort to expand their technological capabilities (UNIDO 2002*a*: 93). Governments can assist firms by maintaining political and macroeconomic stability, creating an institutional framework—including good governance and an incentive system—that encourages firms to engage in this difficult, risky, and costly process—and by insuring flexibility in factor markets and helping firms to overcome market and coordination failures (ibid.).

Because most technological capabilities building requires effort, trial and error, and gaining tacit experience with particular technologies, it is primarily a task that only firms can undertake (Lall 1992: 166). As we now know, building firm-level technological capabilities in developing economies is largely an imitative, rather than an innovative, process that requires firms to import and adapt already existing technologies, rather than engage in basic research or new product innovation. Developing country firms often start this process with very limited technological capabilities. Because of this, they face a particularly daunting set of problems and choices. They must match their choice of foreign technology to local needs, conditions, and constraints (Dahlman *et al*. 1987: 762).

Once firms have narrowed their search to particular technologies, they must decide precisely how to acquire all the elements—information, means, and understanding—associated with their technology choices (ibid. 767). Options include relying on direct foreign investment, licensing agreements, turnkey projects, purchase of individual pieces of capital equipment, and/or acquiring technological capabilities through technical assistance (ibid. 767–9). Having

Asian financial crisis left many domestic plants with large unserviceable debt burdens. Holcim's acquisition of SCCC is consistent with this pattern as SCCC's major stockholder, the Bank of Ayudhya, sold its interest in SCCC to Holcim as part of its debt restructuring.

settled on technology choices and options for acquiring all the elements associated with particular technologies, firms must then invest in the arduous tasks of acquiring the investment, production, and linkage capabilities offered by the technologies they have chosen. Once the technology is installed, emphasis shifts to acquiring production capabilities—or the capability to improve the operation of the factory, to learn how to optimize operation of facilities including raw material control, production scheduling, quality control, troubleshooting, and adaptation of processes and products to changing circumstances, and to repair and maintain equipment as needed (Lall 1992: 171). Finally, firms must develop linkage capabilities that enable them to transmit information, skills, and technology to and receive information, skills, and technology and other inputs from component and raw material suppliers, subcontractors, and technology institutes (ibid.).

Because all firms are embedded in a larger socio-political and economic environment, government policies have enormous impact on whether firms in developing economies invest in building their technological capabilities, how much they invest in capabilities building, and how successful they are in building their capabilities. To begin with, governments must provide sufficient political stability and macroeconomic stability so that firms can reap the gains from long-term investments in building their technological capabilities. Beyond this, governments must establish and sustain a set of institutions—rules of the game—that insure security of property rights and a structure of governance—simple and transparent rules governing government–business interactions—and a government that incites entrepreneurs to invest. In addition to provision of political stability, macroeconomic stability, and an institutional framework and good governance that incites entrepreneurs to take risks and invest, governments must also establish and sustain a long-run vision for industrial growth, insure flexibility in factor markets, finance or provide essential and reliable infrastructure—in transportation, communications, and power—invest in skills building, and help firms overcome market and coordination failures (UNIDO 2002*a*).

6.3 Thai Industrial and Technology Policies and the Siam City Cement Company

How do the prerequisites for the success of technological upgrading activities of private sector firms described above compare with what is known about the Thai government's industrial policies, particularly those affecting the willingness of indigenous firms in Thailand, such as Siam City Cement Public Company Ltd., to invest in technological upgrading? There are two distinct answers to this question. On the one hand, successive Thai governments have an admirable record of providing the basic enabling conditions for substantial private sector investment in industry. The country has a long history of

political stability, particularly within the government's core economic bureaucracy (Rock 1994: 22–4), and a similarly long history of maintaining macroeconomic stability (Rock 1995: 747) and openness to trade, foreign investment, and foreign technology (Pongpaichit 1980).

Following the rise of Marshall Sarit to power in 1958, the government finally and resolutely eschewed an industrial development strategy based on discrimination against Chinese entrepreneurs and development of state-owned enterprises and created the rules of the game, a set of institutions, and a structure of governance that incited the country's Sino-Thai entrepreneurs to invest in manufactures (Muscat 1994: 86–127). Initially, the government's long-run vision for industrial development focused on creating a small number of very large firms in import substitution industries linked to multinational firms in joint ventures (Rock 1995: 750–2), but as the returns to import substitution slowed, the government shifted its industrial development strategy to promote the export of manufactures (ibid. 753–5). There is substantial evidence that the small number of very large Sino-Thai conglomerates promoted by the government's investment promotion agency, the Board of Investment (BOI), responded to these incentives (Suehiro 1992). Their response was, no doubt, reinforced by flexibility in factor markets, particularly for labor (Mabry 1979), by significant, albeit somewhat belated, investments in skills-upgrading and engineering education (Felker 2001: 164–6), and by ample provision of relatively cheap and more or less efficient infrastructure services (Muscat 1994: 94–5).

On the other hand, except for the capability building aspects of the local content and joint venture requirements placed on foreign investors by the BOI (Felker 2001: 139, 167–73), successive Thai governments have been less successful in building and sustaining a set of public sector technological upgrading support policies and institutions. Financial policies aimed at encouraging the private sector to invest in technological upgrading have not had much impact (Arnold *et al.* 2000: 83–8). An early 1990s shift in the Board of Investment's approach to investment promotion which emphasized technological upgrading fared no better (ibid.; Felker 2001: 164–6). While there has been more success with several recent efforts in the Board of Investment and the Ministry of Industry to increase the technological capabilities of Thai firms, these new programs have not contributed to a more rapid diffusion of new technologies (ibid. 170–2).

Neither public sector technology support institutions (Arnold *et al.* 2000: 114–17) nor government-sponsored linkage programs between universities and industries (ibid. 119–20) have been very effective either. And while the government's vendor development program has been more successful, this is largely the result of voluntary efforts on the part of multinational and Thai firms rather than the government's efforts (Felker 2001: 172). Thus it appears that Thailand's public sector technology support institutions have not been as successful as those in Korea, Taiwan Province of China,

Singapore, and Malaysia in promoting technological learning in Thai industrial firms.

But, it is important to note, the weaknesses in Thailand's technology policies and public sector technology institutions do not mean that Thai industrial firms have not made significant investments in acquiring technological capabilities. Rather it appears that the Thai strategy of supporting the development of a small number of large industrial conglomerates linked to multinationals through joint venture and local content requirements alongside Thailand's tradition of openness has contributed to substantial technological learning. This is most clear in resource-based and agro-processing industries (Jomo and Rock 2003: 148–54; Rideout and Allen 1999: 17) and in textiles (Felker 2001: 161). There is growing evidence that this is also true in electronics and automotive parts (Felker 2001: 173; Arnold *et al.* 2000: 53–4). And as is demonstrated below, it appears to be the case in cement.

6.4 Siam City Cement

How has Thailand's industrial development strategy and government technology upgrading policies and institutions affected Siam City Cement Public Company Ltd. (SCCC)? To begin with, government policies in a wide set of domains—from political stability to macroeconomic stability, to openness to trade, foreign investment, and foreign technology, to legal limits on entry of new commercial banks, to the offering of lucrative promotional privileges showered on a small number of what became large industrial conglomerates, to the maintenance of flexibility in factors markets, to the provision of adequate and reliable infrastructure, alongside a clear commitment to private sector-led industrial development—facilitated substantial investments by Thailand's private sector, including substantial recurring long-term investments in cement by SCCC. The responsiveness of private Thai capital to the government's provision of these enabling conditions for rapid private sector industrial growth is testimony to the importance of getting these enabling conditions right.

The founder of SCCC, like the founders of most large Sino-Thai manufacturing companies, took advantage of these initial conditions by linking his interest and investments in cement to the financial interests of senior officials in government[8] and a major commercial bank—the Bank of Ayudhya.[9] Initially, the government provided the land for the factory site and in return held 10% of the company's stock while the founder and the Bank of Ayudhya

[8] For discussion of the necessity and profitability of Sino-Thai entrepreneurs developing effective and enduring links with high-ranking government officials see Girling (1981: 72–84).

[9] For discussion of government policy with respect to commercial banks and the subsequent role of commercial banks in industrial development see Rock (1995: 750).

provided most of the capital.[10] Initial registered capital was 100 million Thai baht.[11] A robust and growing economy, SCCC's links to senior government officials, and its access to credit through the Bank of Ayudhya helped to insure that the company's initial investments in cement were profitable. At the same time, the owners of SCCC did not avail themselves of other government programs. Since cement was never a promoted industry, SCCC never received BOI promotional privileges. Because the import of cement into Thailand was prohibitively expensive, particularly prior to the development of large container ships, the company did not need protection from imports. And because the government's technology support policies and institutions were so weak, SCCC never turned to them for assistance.

That being said, it bears repeating that it is clear that the government provided the enabling conditions, including the rules of the game, a set of institutions, and a structure of governance that incited the country's Sino-Thai entrepreneurs, including those at SCCC, to invest in manufactures. Because of this SCCC has been expanding its investments in cement since 1972. The company's first cement kiln,[12] which was built over 30 years ago (1972), was constructed at the site of a limestone quarry 129 km north of Bangkok on the Friendship Highway, a four-lane road built by USAID between Bangkok and Thailand's northeast. SCCC's first kiln, the first modern dry kiln with a pre-heater in Thailand with a capacity of 600,000 tons, was designed and built as a turnkey project by a European engineering firm contracted by SCCC.

Management at SCCC opted to build a large modern dry rotary kiln with imported equipment and technology provided by an engineering firm in Europe because its major domestic competitors were importing new modern dry rotary kilns. Thus if SCCC wanted to be competitive, it had to keep technological pace with the other large cement firms in Thailand, particularly Siam Cement, a much older and more established firm than SCCC and Thailand's flagship blue-chip industrial company (Muscat 1994: 65, 259–60). In 1977 SCCC was listed on the Stock Exchange of Thailand and SCCC's second kiln came on line in 1981. This kiln has a capacity of 4,400 tons per day or 1.5 million tons per year. It was the largest in Thailand at that time and it was the first kiln in Thailand with a pre-calciner. Like SCCC's first kiln, design and construction of this second kiln was contracted out as a turnkey operation to a European engineering firm.

10 Interestingly enough, SCCC has never asked for or received government promotional privileges from the Board of Investment (BOI) or subsidized loans from the Industrial Finance Corporation of Thailand (IFCT).

11 The government's share has been declining because of the issue of more shares over time.

12 Cement kilns are the core technology in the making of cement. Crushed limestone and other trace elements are burned at very high temperatures (in excess of 1,000 °C) in the kiln to produce a product called clinker. Clinker is then ground into cement in a grinding plant.

Thus for its first two kilns SCCC relied on a European engineering firm to design, purchase, assemble, construct, and import all of the equipment, in an essentially turnkey operation, used for the production of cement. At this point, SCCC appears not to have made significant investments in technological capabilities building or know-how and know-why. In fact, in 1981, when SCCC's second kiln was being built, over 100 foreign engineers oversaw the construction. As the senior vice president for cement manufacture at SCCC said, this was the usual way firms in Thailand acquired cement plants. That is, they routinely hired engineering firms from the US, Western Europe, or Japan to design and then buy all of the equipment, usually from different suppliers in the OECD economies because there is no one turnkey supplier. Once design and purchase of equipment was completed, these firms then constructed turnkey cement plants for their Thai clients. The OECD-based consulting engineering firms contracted to oversee the design, purchase, and construction of a new production line were usually quite reluctant to provide their customers, such as SCCC, with all the engineering drawings. Some suppliers simply refused to provide these drawings.

But as senior engineers at SCCC said, this method for acquiring new plant and equipment resulted in numerous production-related problems that made senior management at SCCC, particularly the senior vice president of cement manufacture, recognize that they had to increase their technological know-how and know-why if they were going to be able to compete successfully in modern cement production. One clear manifestation of the need to acquire technological know-how and know-why, particularly in production capabilities, occurred during the second oil crisis in the late 1970s and early 1980s. At this time, Thailand became concerned that it might not be able to rely on the world's oil supply for future growth. In response, SCCC invested in adaptive technological learning and ultimately was able to improve the firing system in its two kilns so they could be fired by coal lignite rather than bunker fuel. This demonstrated the ability of engineers at SCCC to successfully engage in production process modifications that saved a substantial amount of oil and foreign exchange. This was important because energy costs constitute about 35% of the total cost of making cement. In 1983, SCCC undertook another substantial effort in adaptive technological learning. This time engineers at SCCC altered the production process in its first kiln line by adding a precalciner—this cut fuel use from approximately 900 kcal/kg clinker to approximately 700 kcal/kg clinker. As part of this process modification, engineers at SCCC also added 200,000 tons to the capacity of the first production line (up from 600,000 tons to 800,000 tons). Taken together, the adding of a precalciner and expanding the capacity of its first kiln enabled engineers at SCCC to acquire at least some of the capabilities associated with new (expansion) investment.

In 1987, Thailand's economy started to boom and a rapid increase in the demand for cement was met by imports. This led SCCC to consider adding

an additional production line in factory number 2. At this time, senior managers and engineers at SCCC recognized they could reduce their investment costs if they invested in know-how and know-why technological capabilities building. So senior managers at the company started talking with their equipment suppliers in Germany and Denmark about SCCC making some of the equipment for this next production line. While the German supplier refused to assist SCCC's engineers in technological learning, their supplier in Denmark, F. L. Smidth, agreed to help, if SCCC agreed to compensate them for this assistance. Subsequently, SCCC sent a group of engineers to work with the Danish equipment supplier for the design of SCCC's third cement kiln built in 1987. This kiln has a capacity of 1.75 million tons of clinker per year.

As the design of the third production line was nearing completion, managers at SCCC surveyed local workshops in Thailand to assess their capacity to produce some of the new cement-making equipment for their next kiln. F. L. Smidth, their Danish supplier, sent engineering experts to these Thai workshops with SCCC's engineers and helped them to learn how to produce what was needed. Because of SCCC's good relations with its Danish supplier, most of the equipment for this production line was subsequently made in Thailand by Thai workshops.[13] Through this learning process, overseen by their Danish supplier, engineers at SCCC acquired substantial investment and linkage capabilities. They learned how to carry out investment feasibility studies, organize all activities associated with establishing a new cement plant, and they learned how to manage all of the information, skills, and technology associated with overseeing their Thai and Chinese subcontractors responsible for manufacturing the equipment for their third production kiln.

In 1989, SCCC added yet another 1,750,000 tons per year production line (the company's fourth kiln). This time SCCC did most of the engineering design drawings and it asked its supplier, F. L. Smidth (FLS) to work with it to reduce project costs. FLS agreed to help SCCC, and it assigned a number of its senior engineers to work with SCCC's engineers on this project. This time SCCC sent approximately 40 mechanical and electrical engineers to Denmark for between 6 months and 1 year each to do the design drawings. SCCC's engineers drew on Smidth's 100 years of history in the design and construction of cement plants and on its extensive library. This was a huge learning experience for SCCC's engineers and it enabled them to acquire substantial investment capabilities.

In 1992, SCCC added its fifth production line with a capacity of 10,000 tons per day or 3,000,000 tons per year. At the time, this was (and still is) the largest cement kiln in the world and SCCC worked with its Danish supplier

[13] Some of it, such as the kiln liners, could not be made in Thailand because Thailand lacked the foundry facilities to manufacture this equipment. So this specialized equipment was contracted out to firms in other countries, including China.

to design and build this 'pilot' plant. In 1996, SCCC added its sixth and final production line of yet another 10,000 tons per day or 3,000,000 tons per year.[14] But this time, SCCC and its engineers completed all aspects of this project from design to construction and operation all by themselves. SCCC engineers fully designed the plant, relied on Thai subcontractors and a Chinese subcontractor to manufacture all equipment used at the plant, and they oversaw all elements of construction. In 1981, they used more than 100 foreign engineers to oversee the design, subcontracting, and construction of their second production line, but this time only Thai engineers were involved. Except for certain specialty items, such as kiln liners, that could not be manufactured in Thailand, virtually all of the production equipment was contracted out for manufacture in Thai workshops. SCCC drew on more than 50 Thai contractors to make the equipment and help it install the plant. It managed this process by appointing a very strong team of supervisory engineers from within SCCC to oversee the Thai contractors. As a consequence of this experience in acquiring investment capabilities, SCCC was able to substantially reduce its investment costs.[15]

As a consequence of the currency crisis in 1997, SCCC was pushed by financial circumstances to extend its investments in technological learning by expanding its know-how and know-why in production capabilities. In this instance, production capabilities were improved by the experience gained in systematizing and institutionalizing a total performance development (TPD) approach to solving technical, economic, and environmental problems. The TPD system was modeled on the Quality Circle concept used in Japan. Mr Somboon invented the TPD system as a result of what he learned as an MBA student at Thammasat and he had used it for some years at SCCC. He said it had been a particularly effective means to 'green' SCCC's three plants in Saraburi Province.[16] But because the economic crisis forced them to be more innovative and systematic in lowering their production costs, Mr Somboon started to formalize, systematize, and institutionalize the TPD. He did so by, among other things, grouping the employees at the company's three plants in Saraburi Province into over 700 small teams. He made each team responsible for generating ideas to improve economic efficiency, worker health and safety, and the environment. Teams' ideas were and are vetted in open forums and those thought most worthy of action are then implemented by the teams themselves.

[14] This means that SCCC has two of the three largest kilns in the world; the third is owned by Siam Cement (SC). SC is a well-known Royal Crown property in Thailand.

[15] As the senior vice president for production said, investment costs are about $400 per ton of cement in the US, $200 per ton of cement in Europe, $150–200 per ton of cement in Asia but only $50 per ton of cement in SCCC. Mr Somboon says that SCCC's low investment cost is because of their investment in know-how and know-why.

[16] See discussion below.

Between 2001 and 2003, TPD teams implemented 560 different actions (135 in 2001, 125 in 2002, and 300 in 2003). Of these actions 73 were environmental, 83 related to improving quality, 119 focused on safety, and 285 focused on improving the production process. In 2001, TPD actions implemented saved SCCC 351 million baht. In 2002, TPD actions saved 248 million baht and through August of 2003 TPD actions saved 152 million baht. It is also important to note that all TPD actions do not save money. Those with respect to the environment and health and safety often cost money.

There are numerous specific examples of how Mr Somboon used the TPD to improve the environment. One of the earliest and most interesting involved breaking the land area surrounding each plant into small quadrants and asking TPD teams assigned to each quadrant to identify ways of improving the environment in a quadrant. One of the most popular ideas among TPD teams has been to 'green' each plant site. Tall slender pine trees have been planted to shelter coal lignite, shale, and limestone conveyor belts from the road system within the factory. In numerous instances tree planting has been extended to direct production areas such as areas housing the firm's very large rotary kilns. As a consequence of SCCC's greening program, SCCC's three factory sites, its lab buildings, engineering complex, cafeteria, and its apartments and houses for employees have the feel and look of a college campus. There are numerous small ponds with trees, gardens, and bridges sprinkled throughout the 50 sq. km. area of SCCC's facilities in Saraburi.

But the heart of the TPD system is its use for improving efficiency and quality. For example, electricity costs (baht per KW) rose by nearly 20% between 1998 and 2003. Despite this increase, the actual cost per KW used at SCCC's production facilities has been falling and is well below the power price (through August of 2003 the baht cost per KW is only 69% of the official power price). Mr Somboon attributes these declines in electricity prices to the TPD system. For example, he said that their raw mill in plant no. 3 had a capacity of 400 tons per hour and this led to a cost of 16 KW per ton of product. But by developing and modifying their equipment on this raw mill, they were able to reduce electricity use to 13.5 KW per ton of product. Similar changes were introduced into their grinding mills.

Mr Somboon said they have systematized and institutionalized the TPD system by producing a manual (called a Technical Learning Organization (TLO) Guide Book 2002) that describes how to create a learning organization, institutionalize a learning process, develop performance indicators, and develop and maintain a library of 'best practices'.[17] Another aspect of the

[17] We visited the library while we were at SCCC. It currently consists of hard copy, but everything in the library is being converted to CD-ROMs and will be placed in an electronic library.

TPD system is an annual award system that awards TPD teams plaques for their achievements over the past year. As we toured the company's various facilities at Saraburi, we noticed TPD award plaques prominently displayed in numerous offices.

A particularly good example of how engineers at SCCC went about acquiring production capabilities in raw material control through the TPD system can be found in plant no. 3's year 2003 production cost improvement program. The main foci of this program are on introducing alternative fuel and raw materials usage, saving electrical energy, optimizing production processes, and improving production initiatives. Savings from plant no. 3's alternative fuels and raw materials program were 106 million baht in 2002 and 124 million baht through September of 2003 (see Table 6.1). Fuel savings came from numerous sources such as substituting pet coke (85,000 tons in FY 2002 and 56,000 tons in FY 2003), waste lignite (95,000 tons in FY 2002 and 120,000 tons in FY 2003), and industrial waste water (6,655 tons in FY 2002 and 12,000 tons in FY 2003) for primary fuels.

Process optimization savings—another important element of production capabilities—detailed in Table 6.2, were achieved by, among other things, reducing the blade wear reduction rate on shale crusher 5 and by reducing the clinker factor, or the amount of clinker needed to produce a given amount of cement. Reduction in the clinker factor was accomplished by increasing the percentage of lime in the making of Insee Daeng (an SCCC branded mixed cement product) and Insee Petch (an SCCC branded ordinary Portland cement product). Other significant savings came from better process controls in kilns, the raw mill, the cement mill, and the coal mill (Table 6.2).

As a consequence of attention to improved power management in plant no. 3, engineers at SCCC extended their production capabilities by learning how to reduce the KW per ton of cement which declined from 94.8 in 1999, to

TABLE 6.1. Alternative fuel and raw materials (AFRM) usage in plant 3 TPD program

Plant-level TPD group	Activity	FY 2002 savings (millions of bhat)	FY 2003 savings (millions of bhat)
Fuels	Pet coke utilization and fuels mix	48.7	25.0
AFRM	Bottom and fly ash	42.0	45.0
AFRM	Catalyst	0.2	7.5
AFRM	Waste and wax and used oil	14.97	45.4
AFRM	Gypsum mould use	0.55	1.32
Total savings		106.42	124.22

Source: SCCC interviews.

TABLE 6.2. Process optimization in plant 3 TPD program

Plant-level TPD group	Activity	FY 2002 savings (millions of baht)	FY 2003 savings (millions of baht)
Kiln	Bunker oil reduction	6.3	30.0
AC	Raw material transport	0	5.2
R3–R4	Raw mill process optimization	6.0	0
K1–K4	Coal mill process optimization	4.0	2.1
Z1–Z6	Cement mill process optimization	1.5	9.6
Packing plant	Control weight of cement packing bags	1.2	0
Z1–Z2	Increase % of lime in Insee Daeng	18.7	3.0
Z3–Z6	Increase % of lime in Insee Petch	11.0	14.2
Total savings		48.7	64.1

Source: SCCC interviews.

93.69 in 2000, 91.74 in 2001, and 83.58 in 2002. This enabled plant no. 3 to keep its average cost of power substantially below a rising official price. In addition to shifting to off-peak demand and interruptible service where possible, as indicated in Table 6.3, numerous process modifications in raw mills (such as making modifications of the R1, R2, R3, and R4 separators), in coal mills (such as modifying the separator in coal mill K1), in kiln no. 5 (optimizing all ID fan speed controls), and kiln no. 6 (installing a cascade drive for B- and C-string ID fans), and in cement mills (improving the roller press running factor) also saved energy (see Table 6.3).

One other consequence of SCCC's investments in technological learning is that SCCC has learned how to design and manufacture its own capital equipment, which is marketed on the international market. The best example of this is a separator, the SCCC-SP Separator,[18] with a higher mill capacity

TABLE 6.3. Electricity (power) management in plant 3 TPD program

Plant-level TPD group	Activity	FY 2002 savings (millions of baht)	FY 2003 savings (millions of baht)
Power	On-peak energy reduction (R1–R4)	9.2	16.57
Power	On-peak energy reduction (K1–K4)	1.82	1.94
Power	On-peak energy reduction (Z1–Z6)	−1.58	4.16
Power	Reduce overall peak power	1.68	4.79
Power	Use PEA interruptible rate	15.85	16.36
Total savings		26.94	43.82

Source: SCCC interviews.

[18] Separators are used to separate clinker particles by size as they come out of the kiln (interviews at SCCC).

that is more efficient, less energy using, and less maintenance-intensive than alternatives on the market. This particular separator was developed to overcome a problem associated with a separator purchased and installed in two vertical roller mills that had a milling capacity of 400 tons per day. This separator was part of an expansion project that brought SCCC's second 10,000 tons per day kiln on line. The supplier 'guaranteed' that the separator would meet certain performance expectations (see Table 6.4), but engineers at SCCC could not get the separator to meet those performance expectations. This led them to modify the separator with a rather low cost modification that increased milling capacity and reduced energy consumption. To date SCCC has installed nine of these modified separators in its own facilities and sold modified separators to five other plants, including two Holcim plants in Vietnam, a Union Cement plant in the Philippines, and a Cementos Apasco plant in Mexico.

In addition to investing in production capabilities know-how and know-why that improved the economic performance of its production processes, SCCC extended its production capabilities by becoming a leader in Thailand in quality and environmental management. In 1997, prior to acquisition of minority ownership by Holcim, SCCC received ISO 9002 certification for quality management by BVQI in the UK for several of its plants. In 1999 ISO 9002 certification was extended to another plant by MASCI (a Thai ISO accrediting agency) and in 2002, its final plant received ISO 9000 certification by MASCI. In 1997, it received ISO 14001 certification from BVQI for its environmental management system for plant no. 2. By 1999, all of its plants were ISO 14001 certified by BVQI. In addition, in 1999 its laboratory was ISO 17025 certified (IEC Guide 25 Laboratory Certified) and TISI (Thailand Industrial Standards Institute) certified. This means that it can and does undertake quality tests of cement samples from anywhere in the world. In 2000, the government of Thailand awarded SCCC its Best Practice

TABLE 6.4. Comparison of performance results of purchased separator and results after SCCC modifications

Feature	Feature guaranteed by supplier	Performance before modification	Performance after SCCC modification
Power consumption (KW/t)	15.5	16.5	14.0
Milling capacity (tons per hour)	400 (dry)	390 (wet)	550 (wet)
Residue on sieve			
90 μm (%)	10	15	15
200 μm (%)	1.0	1.2	0.9
Mill vibration (mm/sec)	<6	10–12	7–8

Source: SCCC-SP Separator (SCCC n.d.).

Award for Corporate Good Governance. SCCC was one of two companies in Thailand to receive this award. In 2001, SCCC received ISO 18001 and TISI certification for its occupational health and safety management system.

No other Holcim facility has all four of these ISO (9002, 14001, 17025, and 18001) certifications.[19] Moreover, Holcim has only recently established targets for all of its facilities to be ISO 9000 and ISO 14000 certified by 2004 (Holcim 2002: 8). Finally, SCCC's health and safety is exemplary—it has not had an accident in more than three years. In 2002, SCCC won a national award in Thailand for its excellence in occupational health and safety. And in 2003, SCCC received the National Safety Award from the Thai government.

It is also important to note that SCCC's investment, production, and linkage capabilities extend to the environment. It has installed and operated both electrostatic precipitators (ESP) and bag filters (BF) on all its facilities. In each instance ESPs and BFs were installed when a plant was built. For example, when its Danish supplier was building SCCC's first production line in 1969, which came on line in 1972, it installed an ESP to collect dust. Subsequently SCCC acquired the capabilities to purchase, install, and operate both ESPs and bag-house filters on all of its production lines. By 2002, SCCC had 87 BFs and 9 ESPs installed in factory 1, 168 BFs and 13 ESPs installed in factory 2, and 223 BFs and 13 ESPs installed in factory 3 (SCCC 2002*a*: 10). By 2002, SCCC had installed a total of 488 bag filters and 35 ESPs (ibid.). In addition, when SCCC installed its fourth production line in 1992 of 5,500 tons per day it also installed a waste heat recovery system that generates 8,000 KW of electricity per year. Because SCCC has been so successful in acquiring environmental capabilities, emissions from SCCC's kilns are quite low—dust from the main stacks of each of the company's six kilns varied from 23–85 mg/m^3 between 1999 and 2001, while SO_2 emissions varied from 1.71 ppm to 3.41 ppm in these same stacks (see Tables 6.5–6.7).

Not only is SCCC one of the world's largest producers of cement (it ranks thirteenth in the world), it is apparently quite efficient. This suggests that it has been quite successful in acquiring production capabilities. There are numerous examples of this that come from comparing SCCC to other cement plants 'owned' by the Holcim Group. For example, in 2001, SCCC produced 2.1 times more cement per production employee than the average for all Holcim plants. In addition, the best SCCC plant, plant no. 3, produced 1.7 times more cement per production worker than the average for the top 10% of Holcim plants in 1999. This plant, SCCC's largest, has the world's largest cement kiln and it has a limestone crusher with a capacity of 2,000 tons per hour, a shale crusher with a capacity of 800 tons per hour, two raw mills with a capacity of 1,000 tons per hour, two lignite mills with a capacity of 900 tons

[19] By 2002, 59 of Holcim's 129 plants were ISO 9000 certified, 20 were ISO 14000 certified, and two were OHSAS certified (Holcim 2002: 8).

TABLE 6.5. Average dust emissions at SCCC's kilns (main stack mg/m^3)

Year	Factory 1		Factory 2		Factory 3	
	Kiln 1	Kiln 2	Kiln 3	Kiln 4	Kiln 5	Kiln 6
1999	75	85	59	26	23	34
2000	59	Shutdown	32	29	36	24
2001	Shutdown	Shutdown	40	41	46	45

Source: SCCC (2002*a*: 9).

TABLE 6.6. Average SO_2 emissions at SCCC's kilns (main stack ppm)

Year	Factory 1		Factory 2		Factory 3	
	Kiln 1	Kiln 2	Kiln 3	Kiln 4	Kiln 5	Kiln 6
1999	2.15	2.66	2.40	2.84	2.29	2.43
2000	2.94	Shutdown	2.43	2.18	1.82	1.71
2001	Shutdown	Shutdown	3.26	1.82	3.36	3.41

Source: SCCC (2002*a*: 10).

TABLE 6.7. Average NO_x emissions at SCCC's kilns (main stack ppm)

Year	Factory 1		Factory 2		Factory 3	
	Kiln 1	Kiln 2	Kiln 3	Kiln 4	Kiln 5	Kiln 6
1999	463	338	211	167	201	266
2000	297	Shutdown	296	273	218	348
2001	Shutdown	Shutdown	246	234	263	331

Source: SCCC (2002*a*: 10).

per hour, a kiln with a capacity of 10,000 tons per day, two cement mills with capacities of 900 tons per hour and 560 tons per hour, and a packer with a capacity of 2,000 tons per hour.

The evidence presented above demonstrates that management at SCCC invested substantial time, energy, and resources quite early in the company's history in acquiring investment, production, and linkages capabilities. Among other things, these investments in technological learning and upgrading led to significant improvements in SCCC's production processes, contributed to substantial energy and raw materials savings, and to substantial improvements in the environmental performance of cement production at SCCC. Doing so required managers at SCCC to scour the world for the best and most efficient technologies and to invest in learning how to design, contract out the manufacture, install, operate, and modify the equipment it purchased, including the pollution control equipment, in the OECD

economies. Much of this happened prior to the acquisition of a minority interest in SCCC by the Swiss cement conglomerate.

6.5 SCCC's Joint Venture with Holcim

The East Asian currency cum financial crisis, which started in 1997, hit the Southeast Asian cement industry particularly hard. Large local manufacturers in Indonesia, Malaysia, and Thailand borrowed in international capital markets to ramp up production to meet the growing demand for cement in the region prior to the crisis. New state-of-the-art production facilities were coming on line in each of these economies just as the crisis hit. As the crisis deepened, growth slowed and the construction boom collapsed leaving these large indigenous cement firms with rapidly declining revenues, enormous excess capacity, and large dollar-denominated debts. In numerous instances, debt-distressed local cement companies restructured their debt by selling significant ownership shares to the world's multinational cement conglomerates.

While SCCC was in a better position than most other cement companies in this region,[20] one of its major shareholders, the Bank of Ayudhya, like many financial institutions in Thailand, was deeply in debt. As part of restructuring its debt, the Bank of Ayudhya sold Holcim a 30% share in SCCC in 1999. With their 30% shareholding in SCCC, Holcim was able to place three members on SCCC's Board of Directors. This included the vice chair and SCCC's new CFO, a director of SCCC's ready-made concrete business, and the managing director and CEO of SCCC. Holcim's appointed CFO to SCCC is also on the company's three-member audit committee, and a Holcim manager, the CEO of SCCC, is the chair of SCCC's executive committee. This gives Holcim managers two of the seven seats on SCCC's executive committee (SCC 2002*b*: 4). Below SCCC's Board of Directors and its Executive Committee, there are five major divisions—one each in manufacturing, marketing, finance, human resources, and concrete—within SCCC. Mr Somboon Phuvoravan is the senior vice president for cement manufacture, while Thais also hold senior vice presidencies for marketing and human relations.

When we asked Mr Somboon what SCCC learned from its new relationship with Holcim, he pointed to four things. First, he said Holcim computerized SCCC's entire operation. He sees this as particularly helpful to the engineers who have been provided with laptops while at the same time, the entire 'campus' of their facilities in Saraburi—engineering offices, labs, apartments and homes of the engineers who live on site have been wired into a 24-7

[20] SCCC's foreign debt prior to the crisis was limited to $500 million associated with the purchase of a power plant, a tile and pipe manufacturing business, and a PVC pipe manufacturing facility. SCCC, like other Thai conglomerates, acquired these businesses as part of its diversification strategy. All of these ancillary businesses were sold during the crisis. The revenues from these sales were used to retire SCCC's debt and by 1999 SCCC was debt free.

network. This has increased the productivity of engineers. Computerization was also extended to a just in time or real time cost accounting software system called SAP. This enables every budget manager to track expenditures relative to budget on a daily basis. Second, because Holcim annually benchmarks the performance of each of its cement plants and shares the results with plant managers, company managers at SCCC learned that they were (and are) among Holcim's most productive, efficient, and least polluting plants. There are numerous examples of this. To begin with, SCCC is one of the lowest cost producers of cement in the Holcim Group.[21] SCCC also has an enviable overall equipment efficiency record.[22] In 2002, five of SCCC's six plants had overall equipment efficiency (OEE) records at or above 80% and two production lines had OEEs close to 90%. This was well above the average OEE for all Holcim plants. In fact, of the 10 plants in the Holcim Group with the highest OEEs, five were SCCC plants. Not surprisingly, SCCC is first among all Holcim Group companies in OEE. SCCC also ranks high in terms of continuous hours of operation without breakdown. Five of SCCC's six plants had the highest continuous hours of operation without a breakdown of all Holcim plants in 2002. In addition, four of SCCC's plants had the lowest energy use per kilogram of clinker of all Holcim plants in 2002. SCCC's environmental performance also compares favorably with other Holcim Group plants. For example, Holcim has established emissions targets for existing and new plants for the year 2007 (see Table 6.8). As the data in column 4 show, SCCC already meets most of these standards.

While the managers at SCCC suspected they were good, until the joint venture with Holcim, they never had the data that enabled them to compare their performance to others. Mr Somboon Phuvoravan attributes SCCC's good comparative performance to the newness of their technologies, to the scale of their operations and the size of their kilns, to their long-term initiatives in all aspects of technological learning, to what they have learned from the Holcim Group, and to SCCC's TPD system, which, he says, drives them to continuous economic, production process, quality, safety, health, and environmental improvements.

Third, Holcim has introduced a substantial worldwide Alternative Fuels and Raw Material Program (AFRM) that has been extended to SCCC (Holcim 2002: 20–1). While the engineers at SCCC were experimenting with alternative fuels and raw materials prior to their partnership with Holcim,

[21] The average cost of producing a ton of cement in the Holcim Group in 2001 and 2002 was nearly twice the cost of producing a ton of cement at SCCC. While SCCC was not the lowest cost producer in the Holcim Group, it would have been if one of Holcim's other facilities in another country were not receiving substantial government subsidies. But, it should be noted, SCCC's most efficient plant, plant no. 3, has been the lowest cost producer in the Holcim Group—its cost of producing a ton of cement is about 25% of the cost of producing cement in Holcim plants in the US.

[22] Net operating efficiency is defined as actual hours of operation of a plant in a year relative to plant capacity.

TABLE 6.8. Holcim emission guideline values (EGV) for 2007

Parameter (mg/m^3) at 10% oxygen-dry gas	EGV in mg/m^3		
	For existing plants	For new plants	Current average values at SCCC
Dust	50	30	32.25
NO_x	800	500	300
SO_2	500	400	301
VOC	100	100	
HCL	30	30	

Source: SCCC interviews and Holcim (2002: 25).

Holcim helped them systematize, institute, and launch an aggressive AFRM program. SCCC's AFRM program has led to very substantial increases in the use of alternative fuels and raw material. In fact, the use of alternative fuels and raw materials has increased from 926 tons in 1999, to 10,820 tons in 2000, 209,519 tons in 2001, and 580,377 tons in 2002. In 2002, SCCC's AFRM program was using substantial amounts of waste oil, waste solvents and waxes, sludge fuel, oil drilling mud, wastewater sludge, boiler ash, palm oil shells, and rice husks in its AFRM program (see Table 6.9). In an effort to expand the AFRM program, SCCC has entered into contracts with the Environmental Research Institute (ERIC) of Chulalongkorn University in Thailand in 2000 for a nationwide waste market research study and to Kasetsart University in Thailand in 2002 to identify all the potentially usable industrial wastes within 350 km of its production facilities in Saraburi.

As a consequence of a significant increase in the use of alternative fuels, SCCC has been able to achieve a thermal substitution rate (TSR) of alternative fuels for fossil fuel of 13.8% in 2003. This has saved it 7.2% on its thermal equivalent fossil fuel costs. It expects fuel cost savings to reach 29% of thermal equivalent fossil fuel costs by 2006. It should be noted that this alternative fuels program is in addition to the use of bottom ash/fly ash as alternative raw material. One very positive consequence of SCCC's alternative fuels and raw

TABLE 6.9. Siam City Cement alternative fuel and raw material use (in tons for 2002 and 2003)

Type of AFRM	2002	January–August 2003
Agricultural waste	21,748	35,479
Solid industrial waste	542,223	412,271
Liquid industrial waste	10,433	14,399
Sludge	5,973	3,072

Source: SCCC interviews.

materials program is that it has been able to reduce CO_2 emissions from 870 kg/ton of cement in 1998 to 778 kg/ton of cement in 2001 and 730 kg/ton of cement in 2003. It is hoping to reduce this to 675 kg of CO_2 per ton of cement by 2005. Some of the reduction in the CO_2 intensity in clinker production comes from the use of alternative mineral components that enables it to produce less clinker, thereby reducing fossil fuel use. For example, SCCC has learned, from its involvement in Holcim's strategy to reduce the clinker factor in its operations, that a decrease in the clinker factor (a clinker factor of one requires production of one unit of clinker while a clinker factor of 0.80 requires the production of 80% of one unit of clinker in final clinker product, the rest being made up by mineral components) from roughly 0.80 to roughly 0.75 enables it to reduce CO_2 emissions by 32 kg/ton.

While these options offer substantial natural resources conservation and fuel and raw materials cost savings, particularly since some of the alternative fuels and raw materials are lower cost wastes and by-products, adding them to the kiln requires extensive testing and chemical analysis to determine the impact of each on the quality of cement and emissions (particularly of heavy metals and dioxins). Because of this, SCCC, with the cooperation of Holcim, has upgraded its lab facilities and SCCC has invested in additional in-house monitoring equipment and contracted out additional monitoring of stack emissions for heavy metals and dioxins (to SGS Thailand) because this is particularly difficult to do. To date, its dioxin emissions have been well below the Thai standard of 0.5 TEQ ng/m^3 (Table 6.10). Its heavy metals emissions also appear low (Table 6.11).

Not surprisingly SCCC has developed extensive internal procedures for evaluating the use of particular industrial wastes. Following identification of a particular waste, scientists at SCCC analyze each waste in its labs checking for, among other elements, the heat value of wastes and for the existence of heavy metals. Part of the process used to assess the use of alternative waste streams requires computer simulations of the impact of the use of particular wastes on the production process, including what must be done to maintain constant heat in the kiln to assure constant quality of clinker. Simulation is also made of stack emissions.

While this is going on, members of the Quality, Safety, Health and Environment Committee evaluate the implications of using a particular waste. Once it is decided that a particular waste fuel or raw material can safely be

TABLE 6.10. Dioxin emissions at SCCC during March–July 2002

Source	Stack 1	Stack 2	Stack 3	Stack 4	Stack 5	Stack 6	Stack 7
mg/m^3	0.1395	NA	0.0830	0.0668	0.2261	NA	NA
TEQ in ng/m^3	0.0003	NA	NA	NA	0.0002	NA	NA

Source: SCCC interviews.

TABLE 6.11. Heavy metals in the production process and ESP dust at SCCC

Parameter	Standard limit in clinker (ppm)	Factory 1			Factory 2			Factory 3		
		Kiln feed	Clinker	ESP dust	Kiln feed	Clinker	ESP dust	Kiln feed	Clinker	ESP dust
Ba	—	100	200	60	80	200	10	100	200	100
Cr	150	20	80	60	40	70	40	20	40	20
Ag	—	8	10	6	9	10	10	8	10	7
Pb	100	NA	10	NA	10	10	20	NA	NA	NA
Sb	5	4.1	6	4.6	4.9	7.6	5	4.8	7.7	5.8
As	40	2.9	4.6	2.4	4.6	11.6	5.8	3	6.4	3.8
Cd	1.5	NA	NA	NA	NA	NA	NA	NA	NA	NA
Hg	—	NA	NA	NA	0.39	NA	0.3	0.26	0.07	0.99

Notes: Ba = barium; Cr = chromium; Ag = silver; Pb = lead; Sb = antimony; As = arsenic; Cd = cadmium; Hg = mercury.
Source: SCCC interviews.

burned in a kiln and that use of it is economically beneficial, SCCC signs a contract with the waste generators for waste co-processing. This agreement stipulates the specification of the wastes, the quantity of the waste to be provided, the price, if any, for the waste product, and how it will be shipped. Once the waste is received at SCCC, it is analyzed again in SCCC's labs and procedures for utilizing the waste, maintaining quality control of the production process, and limiting emissions are developed and followed. Records of the outcome of simulations, production trials, and actual production use of various wastes and combinations of wastes are kept in SCCC's Technical Learning Organization Library and made available to others within the SCCC group. One example of this process can be seen in Table 6.12, which reports test results comparing quality aspects of burning rice husks in kilns for fuel as compared to burning lignite.

Finally, because SCCC is so good technically, Mr Somboon has been added to Holcim's corporate-wide Technical Council and Holcim has encouraged SCCC to bid on company-wide RFPs (Requests for Proposals) for technical improvement and training projects within the Holcim system. It has been doing the latter and, as mentioned earlier, last year SCCC earned $10 million by providing technical assistance to other Holcim plants.

6.6 Conclusions

We began this chapter by stating the conventional wisdom that manufacturing firms in developing economies might be able to reduce the energy,

Table 6.12. Test results comparing burning of rice husks and lignite in kilns

Test	Average of daily quality testing reports	
	Rice husk	Lignite
% moisture	12.42	26.74
% volatile matter	57.32	24.58
% ash	16.0	20.49
% fixed carbon	14.26	29.88
% sulphur	0.04	1.86
Heat value (kcal/kg)	3,460	3,925

Source: SCCC interviews.

materials, water, and pollution intensities of their activities simply by opening their economies to trade and investment so enabling local firms to adopt technologies, including pollution control technologies, developed in the OECD economies. Our own work in Chapter 5 on the cement industry—a notoriously dirty industry—suggested that cement firms in four East Asian economies who did this gained significantly large improvements in energy efficiency and even larger reductions in pollution intensity. Because the literature on technological learning and upgrading in local manufacturing firms in developing economies suggests that the improvements in economic and environmental efficiencies manifested in our plant-level data were likely to depend on the willingness of these firms to make substantial investments in technological learning, the focus of this chapter has been on the history of technological learning in one cement company (Siam City Cement Public Company Ltd.) with a particularly good record on energy efficiency and an equally good record on pollution intensity.

Our case study of SCCC provides excellent corroboration for our hypothesis that substantial firm-level investments in technological learning and upgrading are necessary if firms are to reap the full advantages offered by cleaner technologies available in the OECD economies. The case study demonstrates how one local firm keen to enhance its technological capabilities very early in the firm's history used its links to engineering design firms and producers of cement manufacturing equipment in the OECD economies to achieve international best-practice levels of economic and environmental efficiencies. By doing so, SCCC has been able to save natural resources and solve complex environmental problems. While much of this occurred prior to SCCC's joint venture relationship with Holcim, an OECD-based multinational cement conglomerate with an enviable environmental record, it is also clear that SCCC learned from Holcim how to develop and implement a very aggressive alternative fuels and raw materials program that is yielding substantial environmental dividends.

Taken together, the findings from Chapter 5 and this case study suggest that, at least for the cement industry in East Asia, the globalization and consolidation of the world's cement industry is providing important technological and environmental synergies that contribute to better economic and environmental outcomes. This is a heartening finding as it suggests that the rapid shift and expansion of the global cement industry to Asia is likely to go hand in hand with significantly large win–win intensity or technique effects that contribute to a smaller environmental footprint than would be the case if expansion were based on local kiln technologies and local pollution control equipment. But none of this was automatic or likely to happen without the Thai government providing the enabling conditions for the technological upgrading activities of the large indigenous firms that emerged in the Thai economy following government policies to promote them.

7

Impact of Multinational Corporations' Firm-Based Environmental Standards on Subsidiaries and their Suppliers: Evidence from Motorola-Penang[1]

7.1 Introduction

How successful are multinational corporations (MNCs) in extending their firm-based environmental standards to their wholly owned subsidiaries and local suppliers, particularly the small and medium sized firm suppliers in developing economies who operate as part of the global production networks of MNCs? Three developments suggest this is not an idle question. To begin with, the economic influence of MNCs is simply staggering. As Dowell *et al.* (1999: 4) state, the intra-firm transactions of the more than 40,000 MNCs with approximately 250,000 affiliates worldwide account for about 40% of world trade; foreign direct investment is roughly five times official development assistance, and the sales of the ten largest MNCs are larger than the GNP of the 100 poorest countries. This suggests that MNCs along with their affiliates and their suppliers have the potential for exerting substantial influences on local, national, regional, and global environments.

Because most of the value added and employment in industry in most developing countries, including the developing economies of East Asia, is accounted for by small and medium sized firms that lie beyond the reach of most governments' environmental regulatory agencies and because we suspect that the most viable path to technological upgrading and environmental improvement in the low income economies lies in finding ways to increase the participation of indigenous small and medium sized enterprises (SMEs) in the global value chains of multinationals, it is important to ask whether an upgrading strategy based on linking indigenous SMEs to the global value chains of MNCs can also be used to affect the environmental performance of SMEs. While not all the SMEs in any one developing economy are ever likely to be

[1] A revised version of this chapter will appear in a forthcoming issue of the *Journal of Industrial Ecology* and is included with permission from Yale University and the Massachusetts Institute of Technology.

reached through the supply chains of MNCs, there is substantial evidence that governments working in concert with MNCs in vendor development programs linking SMEs to MNCs in some places such as Taiwan Province of China, Malaysia, and Singapore have affected the technological upgrading activities of indigenous small and medium sized firms. To date, there is little rigorous evidence to suggest that these vendor development programs have affected the environmental behavior of small and medium sized firms in the East Asian newly industrializing economies. Yet the linkages between the technological upgrading activities of the large cement firms in East Asia and the industrial environmental outcomes in those firms uncovered in Chapters 5 and 6 suggests that something similar might be at work within SMEs that operate as part of the global value chain of MNCs. Our interest in this issue was further enhanced by a recognition that multinational firm-based environmental standards, which lie at one end of an emerging standards continuum that starts with legally mandated state (local, regional, national, and international) based standards and moves toward voluntary quasi-state-based standards (International Standards Organization), civil society-based standards (CERES' Global Reporting Initiative) and industry-based standards (the chemical industry's Responsible Care program and the semiconductor industry's SEMI S2 standard), appear to be playing an increasingly prominent role in MNC firm-level environmental management (Angel and Rock 2003; Dowell *et al.* 1999). The impact of MNC firm-based standards is likely to grow over time.

As we will argue in the next chapter, this shift toward voluntary firm-based global environmental standards by multinational corporations provides an important opportunity to reinforce the positive environmental technique effects, or reduction in environmental intensities effects (Copeland and Taylor 2003; Repellin-Hill 1999; Wheeler and Martin 1992) of open trade, investment, and technology policies. Of course, this will only happen if firms harmonize up to a more stringent standard than any national standard, rather than race to the bottom by shifting production to developing countries with more lax standards and adopting those lax standards. The concurrent shift, in numerous global firms and industries, away from hierarchical organizational structures (vertical integration) for managing their global operations, toward de-centralized global production networks (Henderson *et al.* 2002) provides additional opportunities for extending these potentially positive technique effects to core MNC firms' subsidiaries and their local suppliers operating in the developing world.

Thus a critical core research question to address in the relatively new research agenda on firm-based standards is, how have firm-based environmental standards used by MNCs to organize their activities in global production networks affected these firms' subsidiaries and their local suppliers in developing economies? As yet, there are no good answers to this question. Because the foreign direct investment-led industrial development strategies of the second tier Southeast Asian newly industrializing economies (Felker

2003; Jomo 2001: 5–6 and 9–13; and Bernard and Ravenhill 1995) provide fertile ground for answering this question, we address this lacuna by presenting a detailed case study of the environmental impact of one multinational electronics firm's—Motorola—internal environmental standards on the firm's wholly owned subsidiary and that subsidiary's local suppliers in the state of Penang in Malaysia.

We chose a firm-level case study approach because it is not possible to assess the impact of firm-level environmental standards without examining, in substantial detail, how individual firms organize their internal efforts (including relations with their subsidiaries) to address their environmental impacts in developing economies and how those subsidiaries organize their interactions with their suppliers in these economies to reduce their environmental impacts. As Rosen *et al.* (2000; 2003) demonstrate these organizational (or transaction costs, governance, and institutional) issues loom large, particularly when they transcend the firm's boundary to include a firm's industry as well as its local and global suppliers. We chose a firm in the electronics industry because this industry is a quintessential exemplar of a relatively new and increasingly important form of multinational enterprise—one that relies heavily on an extensive global production network, or GPN (Henderson *et al.* 2002; Rosen *et al.* 2000; and Hobday 2001). We chose Malaysia, or more precisely the Malaysian state of Penang, because this state's government built its industrial base by offering lucrative promotional privileges to attract wholly owned subsidiaries of OECD-based multinational corporations and by offering additional inducements to encourage them to invest in building the technological capabilities of small local firms who supply these firms' subsidiaries with various parts and components (Rasiah 2001; Deyo *et al.* 2001; and Churchill 1995). Taken together, this combination provides a unique opportunity to examine how firm-based standards work within multinational corporations organized as GPNs and how they are being used by subsidiaries in developing economies to improve their environmental performance and the environmental performance of their local suppliers.

7.2 Globalization, Firm-Based Standards, and Environmental Supply Chain Management

What do we really know about MNC firm-based environmental standards or how OECD-based MNCs respond to the differences in the environmental standards they face in the developed and developing countries in which they operate? To the best of our knowledge, the only non-case-specific and direct evidence on this question is provided by Dowell *et al.* (1999: 11–12), who focus on the environmental practices of 86 American MNCs between 1994 and 1997. More precisely, they empirically assess how these practices, defined

as opting for lax local standards, opting for home country (US) based standards, or leveling up to a common, but more stringent, standard than any national standard, affect firms' market values (Dowell *et al.* 1999: 12). They find market values are significantly larger in firms adopting a common, but more stringent, standard than any national standard (ibid. 16). They also show that relatively few (29%) of the MNCs in their study opted for lax local standards and a race to the bottom, while the majority (54%) opted to harmonize up to a common, but more stringent, standard than any national standard, global environmental standard (ibid.). A small, but rapidly expanding case literature (Chapter 5; Sarkis 2003) supports these findings.

So does virtually all of the systematic indirect evidence which demonstrates that, contrary to the pollution haven hypothesis (Dowell *et al.* 1999: 8–9; Korten 1995; Daly 1994; and Baumol and Oates 1988), positive environmental technique effects—as manifested by declining environmental intensities—are more common (Chapters 3, 5, and 6; Copeland and Taylor 2003; Dean 2002; Reppelin-Hill 1999; Wheeler and Martin 1992; Birdsall and Wheeler 1992) in developing countries with open trade and investment policies than they are in developing countries that discriminate against imports and foreign investment. This suggests that most MNCs are probably, at worst, harmonizing up to at least their OECD-based home country environmental standards, rather than opting for lax standards. These findings undoubtedly reflect the growing pressures MNCs face from their customers in the developed world (Aden and Rock 1999), from their investors (Dasgupta *et al.* 1997; Hamilton 1995), from multi-country environmental directives (Rosen *et al.* 2003) and treaties (Montreal Protocol) and from their neighbors (Aden and Rock 1999; Aden *et al.* 1999; Konar and Cohen 1997) to improve their environmental performance and the environmental performance of their suppliers (Rosen *et al.* 2003: 108).

Given this, how should one go about analyzing the impact of MNC firm-based environmental standards on core MNC firms' subsidiaries and those subsidiaries' suppliers in developing countries? We turned to the few studies of voluntary and common industry-wide standards (King and Lenox 2000; Howard *et al.* 2000; Rosen *et al.* 2000) for guidance.[2] This literature demonstrates that attempts to set and implement voluntary industry-wide environmental standards are neither easy, nor always successful. Much depends on institutional environments and transaction costs. When the institutions supporting firm-based standards are weak and transactions costs high, setting and successfully implementing common industry-wide

[2] We turned to this literature because of its focus on transactions costs and institutions and because the question addressed by this literature, how can firms in the same industry develop and implement common standards, is similar to the question we address, that is, how can a multinational firm get its related 'firms' (subsidiaries and suppliers) to implement its common environmental standards?

standards have been difficult to accomplish. But when standards pass both what the transactions cost economics (TCE) literature labels a 'remediableness' test (Williamson 1996: 138) and what the new institutional economics (NIE) labels a legitimacy test (Rosen *et al*. 2003: 112–16), it is much easier to design and successfully implement them.[3] There are numerous examples to support these conclusions.

In one important case, the US chemical industry's voluntary industry-wide environmental standard, the Responsible Care program, adoption of a common standard in the face of weak institutions (absence of an ability to enforce the standard with penalties and sanctions) encouraged adverse selection (firms with poor environmental records joined to disguise their poor performance) and moral hazard (firms adopted the standard but shirked from implementing it) (Howard *et al*. 2000; King and Lenox 2000). In another case, design and implementation of the semiconductor industry's industry-wide environmental standard (SEMI S2) has been quite successful because the standard proved to be both economically attractive (it passed the 'remediableness' test) and widely supported by the major semiconductor firms in the industry (it passed the legitimacy test) (Rosen *et al*. 2003: 103–23).

In yet another instance, an attempt by OEM computer manufacturers to set a voluntary common industry-wide environmental supply chain standard for parts and component suppliers fell prey to remediableness and legitimacy failures. Remediableness failure occurred because it was difficult to measure the economic benefits of the standard and because the standard was undermined by two more economically attractive alternatives—the International Standards Organization's ISO 14001 environmental management standard and individual corporate reporting (on corporate environmental, health, and safety (EHS) websites) on their suppliers' environmental practices (Rosen *et al*. 2003: 116). Legitimacy failure occurred because the two industry organizations involved in setting the standard lacked both the organizational clout and international reach to get a critical mass of computer OEMs (original equipment manufacturers) and their suppliers to accept the standard (Rosen *et al*. 2003: 115–16).

What these studies suggest is that the analytic frames of transactions cost economics (TCE) and new institutional economics (NIE) are likely to offer particularly useful ways of focusing our case study of the impact Motorola's firm-based environmental standard had on its subsidiary in Malaysia and that subsidiary's suppliers. As Williamson (1996: 136) argues, TCE offers a

[3] The remediableness test (Williamson 1996: 136) requires a standard to be economically more attractive than alternative standards, while the legitimacy test (Rosen *et al*. 2003: 114) requires the standard to be deemed representative of the best interests of the group of firms for whom the standard is designed.

comparative institutional approach to the study of firms and markets; an approach that de-emphasizes the role of technology in favor of a search for mechanisms of governance (institutions) that economize on transactions costs, or what Rosen *et al.* (2000: 90) refer to as the *ex post* costs of executing and administering necessarily incomplete contracts. TCE assumes that the parties to any transaction (whether within a firm or between firms) are more or less rational actors searching for ways (institutional arrangements or governance structures) to minimize transactions costs in a world of necessarily incomplete contracts (ibid. 88).

Because TCE economists view all contracts (or transactions) as necessarily incomplete, these transactions are subject to numerous hazards, particularly expropriation, appropriability, and shirking hazards. Expropriation hazards occur when one party to a transaction purchases specialized equipment that can't easily be redeployed to another use without a loss in productive value, to meet their customer's needs (Williamson 1996: 139). Unless both parties to this transaction agree to build safeguards into the transaction that protect both from expropriation hazards, one or both parties can seek to exploit the other. Buyers can exploit sellers who purchased this specialized equipment by forcing them to take lower prices while sellers can exploit buyers by asking them to pay more or find new suppliers (Rosen *et al.* 2000: 90). Appropriability hazards occur when specialized equipment associated with a proprietary technology is redeployed to other profitable uses (Rosen *et al.* 2000: 90). And shirking occurs when a supplier in a transaction cheats on their contractual obligation (Rosen *et al.* 2000: 90).

As Williamson (1996: 138) says, 'The basic hypothesis out of which transactions costs economics works is that of discriminating alignment: transactions which differ in their attributes, align with different governance structures, so as to effect a transaction cost economizing outcome'. Said another way, as transactions become more complex (as they most necessarily do when one extends them to include environmental considerations) and are hence subject to one or more hazards, both parties search for ways to build safeguards into their transactions to mitigate these hazards. What this means is that all transactions, including intra-firm transactions, have three components—price, a set of hazards, and one or more safeguards designed to make it possible to overcome contractual or transactional impasses (Williamson 1996: 139). When hazards are minimal or non-existent and transactions do not involve any investment in specialized assets, American style traditional arm's-length short-term transactions based on competitive bidding emerge (Taylor and Wiggens 1997: 598; Williamson 1996: 139). But when the hazards associated with investments in specialized assets are involved, firms adopt additional safeguards (new governance structures) by moving away from arm's-length short-term competitive bid contracting to either neoclassical contracts which rely on third parties to resolve conflicts (Rosen *et al.* 2001: 88), or to Japanese-style long-term relational contracts

(Taylor and Wiggens 1997: 598) and joint venture arrangements. Ultimately firms may bring transactions within the firm by vertically integrating.

The new institutional economics (NIE) contribution to a transaction cost approach to understanding firms and markets is to recognize that 'boundedly' rational parties to transactions (Simon 1961: xxiv) are likely to search for ways to either strengthen existing institutions governing their complex transactions or create new and more stable and efficiency-promoting institutions when the need arises (Rosen *et al.* 2000: 112). This most likely happens when transactions for products and processes are new, complex, and have no prior commercial application (Markusen 1995: 181), as when environmental considerations are included as part of these transactions, and/or when there are no agreed upon customs or laws to guide parties in a new set of transactions, such as those relating to firm-based environmental standards. In our concluding section to this chapter, we demonstrate how the insights from the application of TCE and NIE to the study of industry-wide environmental standards can be used to understand how a wholly owned subsidiary of Motorola in Penang used its relationship with its MNC core parent and its local suppliers in Penang to successfully implement a new firm-based environmental standard. But before doing so we describe how Motorola and its major subsidiary in Penang worked to implement the parent firm's global environmental standard.

7.3 Firm-Based Standards at Motorola, Inc. and Motorola-Penang[4]

Motorola's attention to firm-based standards started around 1993 when it began to implement a series of environmental audits of its facilities worldwide.[5] These audits, which were and are headed by the Corporate Environmental Health and Safety Department, routinely assess each site's environmental health and safety (EHS) performance, identify corrective actions, and sometimes result in management reviews by the company's board of directors (Motorola 2002: 29). While in the midst of these site-specific environmental audits, the company moved to a common EHS management systems framework that requires all sites to be ISO 14001 certified and to develop and implement EHS programs that comply with corporate EHS policies (Motorola 2002: 29). Motorola-Penang was audited as part of this process in the early 1990s and, following its audit, the subsidiary

[4] Hereafter we refer to Motorola, Inc. as Motorola and we refer to its subsidiary in Malaysia as Motorola-Penang.

[5] Unless otherwise noted, what follows is based on a series of in-depth interviews conducted in October 2003 and January 2004 with managers, engineers, and EHS professionals at Motorola-Penang.

reorganized its EHS team by replacing an environmental health and safety committee made up of individuals from each department with a freestanding EHS unit. The Penang plant now has an EHS department consisting of three full-time staff that includes two full-time EHS professionals.

Subsequently, Motorola began introducing a set of global firm-based environmental standards. These standards cover three areas: performance, procedures, and suppliers. With respect to operational performance, Motorola has global firm-wide goals for reducing emissions of volatile organic compounds (by 10% a year), hazardous air emissions (10% per year), PFCs (reduce 50% from 1995 levels by 2010), hazardous waste (reduce 10% per year), water use (reduce 10% per year), and energy use (reduce by 10% from 1998 levels by 2003) (Motorola 2002: 30). These operational goals are buttressed by longer-range continuous improvement goals that include achieving zero waste (reuse or recycle all waste materials), benign emissions (eliminate all emissions that are harmful to the environment), and closed loop recycling of all natural resources (Motorola 2002: 30–1). Motorola also has product performance goals that focus on designing products that are recyclable and use less energy and hazardous materials (Motorola 2002: 30).

With respect to procedures, Motorola maintains a suite of specific internal protocols and reporting requirements that must be followed by all plants worldwide. For example, each site is required to report on a standard set of environmental metrics that include a site's volatile organic materials emissions (metric tons per billion dollars of sales), its hazardous air emissions (metric tons per billion dollars of sales), its hazardous wastes (thousands of metric tons per billion dollars of sales), its water use (million cubic meters per billion dollars of sales), its electricity use (billions of kilowatt hours per billion dollars of sales) (Motorola 2002: 32), and its annual EHS compliance record (number of non-compliance notices and fines and penalties) (Motorola 2002: 40).

The firm uses a variety of proprietary protocols and software tools globally, and at each of its subsidiaries, to drive it toward continuous environmental improvement. An internal to Motorola Toxicity Index, which identifies each of the chemicals used in each product and weights each chemical by its toxicity, enables the company to develop a simple aggregate measure of the toxicity of each product so that it can focus its efforts on corporate and site-specific goals to reduce the toxicity of its products. Another tool, the Green Design Advisor (GDA), developed in conjunction with Motorola's Real Environmental Assessment Lab (REAL) in Wiesbaden, Germany and a local university is used to design-in recycle-ability of new products while designing-out toxicity. As a design engineer at Motorola-Penang said, she is constantly in touch with her colleagues at REAL for technical advice about how to design new products so as to improve their environmental performance. As she said, Motorola-Penang uses the GDA very early in the design of new products to identify the most cost-effective way to meet recyclability

targets, particularly those recently established by the European Union's new Waste in Electrical and Electronic Equipment Initiative (WEEE).[6] And as she also said, she also draws on the work of Motorola's Environmental Materials Assessment Lab (EMAL) in Tianjin, China to help minimize the use of hazardous materials in final products. Consultation with this lab is helping the subsidiary prepare to meet the European Union's new Reduction of Hazardous Substances (RoHS) Directive, which sets very stringent limits on the amount of hazardous wastes that can be embedded in electrical and electronics products.[7] The company also has a list (the W 18 specifications) of banned substances and substances that can only be used if they fall below certain concentration levels (parts per million). Finally, Motorola has recently developed a new environmental assessment tool, the Product Environmental Template (PET). The PET enables Motorola and its subsidiaries to track the use of banned/limited use substances in products (the W 18 specifications), the energy efficiency of products, the overall toxicity of a product (Motorola's Toxicity Index), and the degree to which new products meet the two new European Union environmental initiatives/directives described above.

Motorola has numerous requirements of suppliers and two protocols to help it track suppliers', and its own, compliance with its environmental expectations. To begin with, all first-tier-qualified suppliers must be ISO 14001 certified.[8] Because Motorola eliminated CFCs from its own manufacturing processes worldwide in 1992, suppliers are not permitted to manufacture products for Motorola using ozone-depleting substances. Third,

[6] For communications products, such as those produced by Motorola-Penang, the WEEE Directive requires that 75% of any such product must be recyclable while 65% of it must be recovered (information provided by Motorola-Penang). Motorola-Penang has sent several products to REAL for GDA recyclability evaluations. These tests give them detailed information on the difficulty and cost of disassembling a product by, for example, determining how costly it is to remove glues and solders. These tests also come back with an overall GDA number, which indicates whether or not the product meets the EU's WEEE recycling requirements.

[7] There is some disagreement about the RoHS Directive. Engineers at Motorola-Penang believe that RoHS bans the use of Pb, Cd, Cr (VI), HG, PBB, and PBDE, but has not yet set the threshold limits a product must meet to satisfy these restrictions (information provided by Motorola-Penang). Our interviewees at Agilent Technologies in Penang said they believe the threshold limits will be as follows. The use of mercury will be restricted to 0.1% by weight not to exceed 1,000 ppm; cadmium to 0.01% by weight not to exceed 100 ppm; lead to 0.01% by weight not to exceed 1,000 ppm, Cr (VI) to 0.1% by weight not to exceed 1,000 ppm and polybrominated diphenyl ethers by 0.1% by weight not to exceed 1,000 ppm (information provided by Agilent Technologies in Penang). Because of these stringent requirements, Motorola-Penang has sent fully loaded (populated) printed wiring boards (PWBs) to the REAL lab in Germany for analysis. The REAL facilities have developed a non-destructive method of screening the PWB for hazardous materials using sophisticated X-ray machines (XRF).

[8] Motorola maintains a global preferred supplier list. Suppliers on this list are qualified to provide components to Motorola plants worldwide. Generally a plant must source from a preferred supplier. This is having important consequences for local suppliers to plants—the type of local firm–supplier linkages involving technological upgrading are becoming less prevalent as plants are required to use preferred suppliers.

suppliers must complete detailed materials disclosure sheets for all goods supplied. These sheets identify the use of specific named materials (e.g. lead and all heavy metals) in components supplied to the MNC, the amount of those materials embedded in a product supplied, and, not surprisingly, the information provided in these data sheets are a key tool in monitoring overall product design.

These requirements are 'enforced' by the use of two protocols. A traditional supply management tool, the Parts Information Management System (PIMS) is an electronic tool used by Motorola to identify each part in each product by a part number, the worldwide first tier suppliers who supply the part, and the technical specifications of the part, including the W 18 specifications of the part. Because of the pressing need to gather more environmental information on purchased parts and suppliers, EHS professionals in Motorola augmented the PIMS with the Environmental Data Management Team (EDMT). EDMT electronically tracks each part in each product by part number, by preferred global supplier with contact information, by the amount of hazardous materials in the part, and by the name of each hazardous chemical embedded in the part. The company is currently integrating the EDMT protocol with the more traditional PIMS tool. Once this is completed, Motorola and each of its subsidiaries will be able to electronically identify each part in each Motorola product by a part number, by preferred global supplier with contact information, by technical specifications (including the W 18 specifications), and by toxic substance and toxicity. Engineers and supply chain managers at Motorola-Penang view the integration of the EDMT with PIMS as an indication of the degree to which environmental considerations are being integrated into Motorola's basic management and decision-making processes.

This system of protocols and tools is increasingly being integrated by a very detailed and corporate-wide environmental approval process for new products, the M Gates process, that helps ensure new products meet Motorola's environmentally preferred products (EPP) requirements for new products. The EPP requirements for new products are aimed at insuring that Motorola products will meet the two new environmental initiatives/directives of the European Union. As mentioned earlier, one of these, the Reduction of Hazardous Substances (RoHS) Directive, places very stringent limits on the amount of hazardous substances that can be embedded in electrical and electronics products. The other, the European Waste in Electrical and Electronic Equipment Initiative (WEEE) places equally stringent recyclability requirements on electrical and electronics products.

The M Gates are a series of choke points that each new product must go through from initial design, to manufacture, to distribution, to product take-back and product recycling. As one design engineer at Motorola-Penang said, the M Gates–EPP process relies heavily on the suite of environmental protocols and tools developed by Motorola—the Toxicity Index, the Green Design

Advisor, the Environmental Data Management Team, the Parts Information Management System, and the Product Environmental Template—to improve the environmental performance of the company, its subsidiaries, its suppliers, and its products. While this entire system is not completely integrated or fully developed, concern over Motorola's ability to meet the requirements of the European Union's RoHS Directive and the WEEE Initiative appears to be driving managers, design and manufacturing engineers, supply chain managers, and EHS professionals, at least at Motorola-Penang, to successfully integrate these systems into one unified environmental management system for new products. As one design engineer at Motorola-Penang said to us, this whole process allows them to do a complete environmental risk assessment of each new product that focuses on a product's waste characteristics, its disassembly characteristics, and its recyclability.

How have Motorola's global firm-based standards affected its wholly owned subsidiary in Penang and that subsidiary's suppliers in Penang and Malaysia? There are several answers to this question. Because Motorola benchmarks individual plants against firm-wide operational and product performance standards, the Penang plant is benchmarked on such performance measures as water use (liters per person hour), electricity usage (KW per product unit), hazardous waste (thousands of metric tons per billion dollars of sales), and waste recycling (% recycled) using an internal computerized reporting and tracking system. Each site has access to this system allowing them to compare themselves to all other sites and to the company's overall environmental performance. Site-specific information from this system is used by Motorola to compile the annual data on corporate performance that appears in the company's Global Corporate Citizenship Report.

Managers in Motorola-Penang noted that this firm-based benchmarking practice has resulted in substantial improvements in environmental performance at the plant. For example, there has been a 75% reduction in their use of hazardous materials (per unit built) between 2000 and 2003, a 100% increase in their scrap recycling rate between 2000 and 2003, and water use has declined from 35 liters per person hour in 2000 to 15 liters per person hour in 2003.[9] This kind of facility-level environmental progress at Motorola-Penang was facilitated by the M Gates process, which permits those in charge of the M Gates' choke points to adhere to very tough standards, particularly for the introduction of new chemicals. As one engineer at Motorola-Penang said to us, it is very difficult to obtain approval for the introduction of new chemicals at Motorola-Penang. If someone wants to do this, they will have to demonstrate that there is no alternative.

[9] Prior to 2000, water use was even higher, but in 1994 Motorola-Penang shifted from a terpene wash of solder paste to a re-flow furnace wash that enabled them to adopt a no-clean technology for applying a newly tin/lead based solder paste in the re-flow furnace. This saved substantial amounts of water and nitrogen, a particularly expensive chemical.

Motorola-Penang also has an aggressive product take-back program called the Green Malaysia Program (GMP). To date, the GMP has emphasized recycling cell batteries, one of Motorola-Penang's major products. Part of this program consists of a traveling road show that sends Motorola-Penang EHS personnel to work with their dealers in each Malaysian state, publicize the program, and set up procedures for collecting cell batteries. So far, the program has collected over 100,000 kilograms of batteries and over 7,000 kilograms of batteries from the program have been shipped to a Motorola approved recycling facility in Korea. Motorola has awarded Motorola-Penang a corporate environmental award for this program.

Meeting these and other corporate environmental objectives has also forced Motorola-Penang to work more closely with its suppliers, particularly its first tier suppliers. This started more than 10 years ago when engineers realized they could not meet Motorola's deadline for phasing out CFCs without getting their suppliers to eliminate the use of CFCs in the parts they supplied to Motorola-Penang. More recently, Motorola-Penang has been focusing on how to reduce the use of toxics, particularly lead for soldering and other chemicals in cleaning agents and fluxes. As with CFCs, their work within Motorola-Penang on reducing the amount of toxics and toxicity of their products quickly led them to realize that it would be difficult to reduce the use of numerous toxics unless they worked with their suppliers. Because of this, the engineers and EHS professionals at Motorola-Penang said that most of their work with suppliers focuses on the concrete problems associated with the elimination and/or reduction in the use of particular toxic chemicals. Only after this has been completed do they work with suppliers on broader EHS issues and ISO 14000 certification.

By far the most interesting aspect of the global firm-based standards in use at Motorola-Penang relates to its programs to reduce the use of lead and other metal toxics, particularly halogen and cadmium, in both products and production processes. As indicated, Motorola has global firm-wide goals to reduce the use of hazardous materials and to design products in ways such that any remaining hazardous materials, along with other materials, can be recaptured in recycling. While this has, for some time, been a significant part of Motorola's continuous environmental improvement program, regulatory developments in Japan,[10] the European Union,[11] California,[12] and

[10] In the mid-1990s, there was discussion in Japan about requiring all electronics products to be lead-free.

[11] The European Waste in Electrical and Electronic Equipment Initiative (WEEE) is to be formally adopted by each member state of the EU by August 2004. The recycling and recovery target rates for this initiative are to be achieved on all designated products by July 2006. The Restrictions on Hazardous Substances Directive (RoHS) bans the use of heavy metals in the manufacture of electronic equipment. It takes effect on July 1, 2006.

[12] Because of California's Proposition 65, Motorola-Penang is searching for a replacement for PVC material that uses lead as a stabilizer. While it has discovered a replacement material that has the same properties as the lead stabilizer, the replacement is much more expensive.

China[13] suggested that Motorola-Penang's continued access to these markets might well depend on its ability to meet new and stringent hazardous substances requirements, such as the EU's RoHS Directive, and equally stringent take-back and recycling requirements, such as the EU's WEEE Initiative.

Faced with this problem, engineers and the EHS department at Motorola-Penang turned to Motorola's Corporate EHS Department, the REAL lab in Germany, and the EMA lab in China for help on how it might meet these new regulations. Much of the initial back and forth between the engineers and the EHS Department at Motorola-Penang and Motorola's Corporate EHS Department focused on deciding how to interpret and define the EU's directive banning the use of, or severely restricting the use of, certain hazardous substances in each 'homogenous element' in each manufactured product. Personnel at Motorola-Penang argued for a broad definition of the term 'homogenous element',[14] while personnel at the Corporate EHS Department argued for a strict and narrow definition of this term.[15] Reaching agreement on definition of this term was absolutely necessary both because the EU RoHS Directive failed to define this term and because Motorola-Penang could not use the suite of environmental tools developed by Motorola to redesign its products so they would meet this requirement until the term was defined.[16] As design and EHS engineers at Motorola-Penang said, there was a vigorous debate on this topic, within Motorola-Penang and within Motorola. In the end, Motorola decided that the term 'homogenous element' would be applied to each distinct element in each distinct part in each Motorola product. This meant, for example, that each of the elements—shields, capacitors, resistors, inductors, and switches—in a printed wiring board (PWB) would have to meet the RoHS requirements.

Once this decision was reached, senior managers in Motorola-Penang brought its EHS personnel, its design engineers, manufacturing engineers, and its supply-chain managers together to sort through how the subsidiary would organize itself and how it would interact with its suppliers to meet these requirements. This ad hoc group and senior managers ultimately settled

[13] The Ministry of Information Industries in China is considering adopting the EU RoHS and WEEE Directives as standards for China.

[14] For example, they advocated that a printed wiring board (PWB) in a product be considered a homogenous element.

[15] The Corporate EHS Department proposed that each independent element of the PWB—resistors, capacitors, shields, inductors, and switches—was a homogenous element, while the PWB itself was not.

[16] This was because new product designers had to know whether they were being required to eliminate or severely restrict a toxic substance in a PWB or in each element of the PWB. As an EHS engineer at Motorola-Penang said, it is much easier to meet a regulation governing the amount of a 'banned' chemical in a PWB than it is to meet that regulation for each 'part' in a PWB.

on the use of Motorola's Product Environmental Template (PET) to organize this work and track product development and progress. Following this, engineers at Motorola-Penang broke each product down into its constituent 'homogenous elements' and analyzed each element to determine whether it met the RoHS Directive. Because some of these homogenous elements were provided to Motorola-Penang by local and/or global suppliers, Motorola-Penang began asking its suppliers to provide additional detailed documentation on the use of hazardous materials in the production of the parts they supplied. This documentation was double checked by scientists at Motorola-Penang.[17] Through this process, Motorola-Penang learned that most of their existing products were not EU compliant. They also learned that it would be too expensive to redesign existing products, which they subsequently labeled 'legacies'. Not surprisingly, they decided to phase out their 'legacies' over time while they designed new products to meet the EU RoHS Directive and WEEE Initiative.

Because of the way Motorola defined the term 'homogenous element', redesigning a product meant redesigning each homogenous element of a product. They modified the PET template to take account of this by using it to identify each homogenous element of a product, identifying all of the materials, including hazardous materials in the element, and comparing findings for the homogenous element to the relevant RoHS standard. Because there are often literally hundreds of 'homogenous elements' in Motorola-Penang's products, this is a particularly laborious and difficult process. But once completed, information developed from this process is fed into Motorola's EDMT/PIMS tracking system for parts by, for example, adding W 18 specifications for a part developed from their PET analysis of the part.

Because Motorola-Penang relies on a relatively large number of local and global suppliers for parts, the subsidiary began working much closer with suppliers, particularly its first tier global suppliers, to determine whether or not parts in particular met the RoHS and WEEE Directive/Initiative. To begin with, as mentioned earlier, each of the subsidiary's first tier suppliers was asked to provide additional detailed documentation of the toxics used and the amount of a toxic chemical used in the manufacture of parts they supplied. This information is double checked by scientists in one of Motorola's labs. Because each preferred supplier is designated by Motorola-Penang as a preferred supplier 'commodity by commodity' or 'part by part', the resulting verified information is integrated into the EDMT/PIMS electronic parts network (as part of the W 18 specifications) used by Motorola to identify all aspects of particular parts and suppliers.

[17] For example, the REAL lab in Germany crushes PWBs for Motorola-Penang to determine what toxic chemicals are embedded in the PWBs and what the weight and concentration of those chemicals are in PWBs.

But work with suppliers often extends well beyond requests for additional information and testing of supplied parts or commodities. Increasingly, Motorola and Motorola-Penang have been forced to work closely with suppliers and dealers on numerous environmental problems related to increasing the compliance rate of Motorola's and Motorola-Penang's products with RoHS and WEEE. In one instance, Motorola-Penang worked very closely with several chemical suppliers,[18] other Motorola subsidiaries, and Motorola to develop a new no-clean flux tin/lead (essentially lead-free) solder paste. Because this lead-free solder paste was developed jointly by Motorola and several of its suppliers, Motorola gets a percentage of the profits its suppliers earn from selling this new product. As one of the engineers at Motorola-Penang said, this whole process took two years and a lot of cooperation between Motorola, its subsidiaries, and its suppliers. A Motorola site in the US focused on paste design, one in the UK looked at the impact of the new design on production processes, while Motorola-Penang did the reliability tests for the new product. All the information developed as a result was shared with the suppliers of the new product.

A similar process was used in developing halogen-free PWBs and FLEX.[19] In this instance, Motorola and its subsidiaries, including Motorola-Penang, worked with both PWBs and FLEX manufacturers and their raw material suppliers to reduce the amount of halogen in PWBs and FLEX. Following successful adoption of lead-free and halogen-free raw materials for the manufacture of PWBs and FLEX, Motorola and Motorola-Penang worked with key dealers and repair shops, both of whom raised questions about the reliability of the new products and how to repair them. Subsequently, Motorola produced a new internal technical manual for these new products that detailed the new specifications and the problems associated with them.

In another instance, Motorola-Penang worked closely with its Indian suppliers of leather cases for hand phones produced by Motorola-Penang to reduce the level of chromium (Cr (VI)) in these cases. This required working with chemical suppliers and leather suppliers to find an alternative process for 'softening' the leather cases. As a result, the leather suppliers have been able to reduce the concentration of chromium by 99.99%. While the suppliers cannot yet meet the stringent EU RoHS Directive for chromium, they are getting close. In yet another instance, engineers at Motorola, including those at Motorola-Penang, worked with suppliers to eliminate cadmium in a no-spark paint they make for use on oilrigs. While the engineers and suppliers, who worked closely together on this project, eventually discovered an alternative, it took substantial time, energy, and resources to produce an alternative no-spark paint, test it to insure that it worked, get it

[18] One supplier was a US-based supplier, while another was a Malaysian supplier.

[19] FLEX refers to flexible wiring 'boards'. FLEX is used in numerous, particularly small, electronics products such as cell phones.

certified by certifying bodies in the US and Europe, and convince their customers to use it.

7.4 TCE, NIE, and Motorola's Firm-Based Standards

We close by suggesting how the insights from transaction cost economics (TCE) and the new institutional economics (NIE) can be used to understand how the adoption of a new set of global firm-wide environmental standards by Motorola, particularly those associated with the EU's RoHS Directive and WEEE Initiative, affected Motorola-Penang's relationships (transactions) with Motorola, Motorola's other subsidiaries, and Motorola's environmental labs as well as with Motorola-Penang's suppliers to enable it and its suppliers to meet these new firm-based standards. As is well known, TCE uses individual transactions as the unit of analysis (Williamson 1981: 1543) and it focuses on, among other things, explaining why some transactions between firms are market or quasi-market based (the buy decision), while in other instances firms opt to internalize transactions within the firm (the make decision).

As TCE economists have demonstrated 'make or buy' decisions are based on the attributes of particular recurring transactions (Williamson 1981). When transactions are relatively new, complex, uncertain, and based on assets with high asset specificity,[20] firms are likely to 'make' rather than 'buy' simply because at the margin, the net benefits of negotiating and executing market contracts under these circumstances, which are prone to severe expropriation, appropriability, and shirking hazards, are likely to be lower than the net benefits associated with bringing these transactions in-house by exercising the 'make' decision (Williamson 1981: 1547, 1549).[21]

As our case study demonstrates, the transactions associated with implementing Motorola's new firm-based standards, particularly those surrounding the firm's efforts to meet the EU's RoHS Directive and WEEE Initiative were new, complex, uncertain, and based on assets with high asset specificity. These transactions were complex because they involved analyzing numerous

[20] As mentioned earlier, asset specificity refers to an asset whose value in use declines when it is shifted from its primary use to other uses. As Williamson (1996: 1547) says, asset specificity can be based on location, a physical asset, or human capital that turns large number arm's-length contracting into a bilateral relationship subject to numerous hazards that can only be corrected by moving away from arm's-length contracting to more complex contracting arrangements or to internal organization.

[21] There are numerous reasons for why this is the case. For example, new, complex transactions with uncertain outcomes are likely to lead to disagreements about how to proceed. If such transactions are market-based, dispute resolution can be costly, but if they take place within the firm, they can be adjudicated by fiat (Williamson 1981: 1549).

products with very large numbers of newly defined homogenous elements[22] with significantly different environmental characteristics that were largely unknown. They were uncertain and risky because little was known about the environmental characteristics of most homogenous elements, because the firm-based standards Motorola adopted to meet the EU RoHS and WEEE Directive/Initiative required Motorola to adopt a definition for the term 'homogenous element' prior to the emergence of a clear definition of that term within the EU[23] and because it required Motorola to adopt particularlimits on individual hazardous substances that may not, in the end, be consistent with the standards adopted by individual countries within the EU.[24] Moreover, most of the environmental transactions between Motorola-Penang and the rest of Motorola were structured around a suite of proprietary assets—the Toxicity Index, the PIMS, the EDMT, the PET, the EPP, and the GDA—with very high asset specificity that were developed solely (the EDMT, the GDA, and the PET) to enable Motorola, its subsidiaries, and its labs to meet its new firm-based environmental standards or were bent (the Toxicity Index and the PIMS) to serve this purpose.

Because of these attributes, it is not particularly surprising that Motorola opted to make rather than buy its new standards or that most of the transactions Motorola-Penang had to make to meet the new standards were internal to the firm decisions. While this conclusion may seem trivial, it is not. As the discussion in Section 7.2 of industry-based standards suggests, Motorola might have decided to work with others in its industry (consumer electronics) to develop an industry-based rather than a firm-based standard. Apparently, all of the transactions costs and governance problems identified by the TCE and NIE literature associated with the development of industry-based standards delineated in Section 7.2 led Motorola to opt for firm-based as opposed to industry-based standards. Alternatively, Motorola could have turned to either CERES or one of the big accounting firms for market-based assistance in developing its firm-based environmental standards, but it did not, probably because of the high transactions costs associated with doing so.

But these are not the only insights from TCE that help us understand why Motorola-Penang relied so heavily on 'make' (internal) rather than 'buy' (market) transactions as it set out to meet Motorola's new firm-based standards. TCE offers an additional and powerful reason for why firms prefer to 'make' as opposed to 'buy', that is, it is very difficult to 'buy' new

[22] As one engineer said to us, even a relatively small PWB has literally hundreds of homogenous elements.

[23] As another engineer said to us, the EU has not yet announced whether the term 'homogenous element' applies to the product (as a cell phone), a particular part of a product (FLEX in a cell phone), or all of the constituent parts in the FLEX.

[24] As one engineer said to us, the EU directives are guidelines and individual countries may or may not adopt those guidelines.

technologies with significant tacit—that is, substantial learning by doing—elements (Williamson 1981: 1562). As the engineers at Motorola-Penang said to us, tacitness—learning by doing—has been a vitally important element of implementation of Motorola's global firm-based standards at Motorola-Penang. Because of this, the 'make' decision appears to have passed the remediableness test. That is, 'making' these standards was more economically attractive than 'buying' them. This, no doubt, reflected the twin problems of information asymmetry[25] and team organization[26] associated with the buying of new technologies characterized by high tacitness.

The new institutional economics (NIE) offers additional insights into why Motorola opted for the 'make' as opposed to a 'buy' decision in its development of new environmental standards for its products. Doing so enabled the new standards to easily pass what NIE refers to as the legitimacy test (Rosen *et al.* 2003: 112)—the acceptance of the standard by all parts of Motorola, including Motorola-Penang. As Rosen *et al.* (2003) have demonstrated, the attempt to set an industry-wide environmental supply chain standard for OEM computer manufacturers failed because the standard was never accepted as legitimately meeting the needs of OEM computer manufacturers. Motorola's new firm-based standards might have similarly fallen victim to a lack of legitimacy. There was some evidence that this might happen. As one of the EHS engineers at Motorola-Penang said, when she started working on the RoHS Directive and the WEEE Initiative in the late 1990s, no one outside the EHS department in Motorola-Penang took her seriously. She said her requests for information or assistance from new product design engineers, production engineers, supply managers, and salespersons were usually turned down with a simple, 'We don't have time for that'.

Three developments worked to secure the legitimacy of Motorola's new firm-based environmental standards. First, the EU formally approved the WEEE Initiative in February 2003. This made it clear to everyone for the first time that the RoHS Directive and the WEEE Initiative might, in fact, succeed in becoming new binding regulations. Second, Motorola announced a major effort within Motorola to explore what it would take to become compliant with these new directives. This subsequently led to the development of Motorola's new firm-based standards and the very process of a firm-wide global effort to develop new standards helped legitimize the requests from EHS engineers regarding those standards in the eyes of design engineers, production engineers, supply chain managers, and salespersons at

[25] Information asymmetry problems occur in 'buy'-based technology transfer agreements (licenses) because the seller knows much more about the technology than the buyer (Williamson 1981: 1562).

[26] Team organization problems occur in buy-based technology transfer agreements because, as Williamson (1981: 1562) says, 'Where the requisite information is distributed among a number of individuals all of whom understand their specialty in only a tacit, intuitive way, a simple contract to transfer the technology cannot be derived'.

Motorola-Penang. Finally, Motorola-Penang's Country Manager organized a collective team effort, involving every relevant department in Motorola-Penang, to ensure that Motorola-Penang would have substantial input into the final firm-based standards adopted by Motorola and to ensure the new standards were viewed as legitimate by all relevant departments and employees in Motorola-Penang. As the EHS engineer at Motorola-Penang said, as a result of these developments, her work with her colleagues on these standards at Motorola-Penang changed. Now product design engineers seek her advice when they are designing new products. So do supply managers who ask for her help in educating Motorola-Penang's suppliers.

Finally, what insights does TCE offer into the evolving nature of Motorola-Penang's relationships regarding Motorola's new firm-based standards? There are three answers to this question. First, prior to the adoption by the EU of the WEEE Initiative in February 2003, which helped legitimize Motorola's new firm-based standard, many of Motorola-Penang's suppliers were as dismissive of the requests by Motorola-Penang's EHS engineers regarding RoHS and WEEE as design production and supply chain managers were inside Motorola-Penang. As an EHS engineer said to us, prior to the formal adoption of the WEEE Initiative both local (in Malaysia) and global suppliers said they supplied too little product to Motorola-Penang to go to the trouble and effort required to become RoHS and WEEE compliant. They said that if Motorola-Penang insisted, they would simply stop supplying parts and components to Motorola-Penang. Following the formal adoption of the WEEE Initiative and indications that the RoHS Directive would soon be adopted, suppliers began getting similar requests from other buyers. This helped legitimize the requests made of suppliers by EHS engineers at Motorola-Penang. Subsequently, suppliers began developing products that exceeded Motorola-Penang's W 18 specifications and they began marketing them with the subsidiary's EHS engineers and supply chain managers.

Because Motorola-Penang now needed much more detailed information from suppliers and because it needed their assistance and willingness to redesign the parts and components they supplied to Motorola-Penang, supply chain managers at Motorola-Penang were forced, as the TCE literature suggests they might be, to move away from arm's-length competitive bidding style contracts, particularly with their first tier suppliers, toward relational contracting that required the sharing of proprietary information. As mentioned earlier, this happened when engineers at Motorola-Penang worked closely with chemical suppliers to develop a no-clean lead-free solder paste; it happened when other engineers worked with PWB and FLEX suppliers to develop halogen-free and lead-free PWBs and FLEX; and it also happened when chemists worked with chemical and leather suppliers to develop chromium-free leather cases for Motorola-Penang's handheld phones. But there is little evidence that these kinds of practices were extended to

Motorola-Penang's second tier suppliers as those relationships continue to be characterized by traditional arm's-length competitive bidding. Interviews with several of Motorola's second tier suppliers suggested why this was the case. For the most part these secondary suppliers are providing simple parts with known environmental characteristics, such as box-housings for PWBs. Production of these parts does not depend on suppliers purchasing assets with high asset specificity. Put another way, because these parts are simple, because it is easy for the buyer to assess quality, and because they do not, by and large, bear directly on the ability of Motorola-Penang to meet Motorola's new firm-based standards, as predicted by the TCE literature, simple arm's-length competitive bidding contracts are the most efficient means of contracting with most second tier suppliers.

8

Global Standards and the Environmental Performance of Industry

8.1 Introduction

This chapter draws together the evidence of the last three chapters to consider the emergence of global standards as a driver of improvements in the environmental performance of industry. Our particular focus is the growing importance of firm-based global environmental standards as an alternative to the more widely recognized state-centered approaches to setting and implementing environmental standards. Increasing numbers of multinational firms (MNCs) are adopting uniform approaches to environmental management across all of their facilities worldwide, including in some cases process- and performance-based environmental standards. Such intra-firm standards have even broader reach when they are also applied to the suppliers of the MNCs as part of standardized supply chain management. In this chapter we examine the rationale behind the adoption of firm-based approaches to global environmental standards, and whether such firm-based approaches add value to traditional state-centered environmental regulation and governance. Why are firm-based global standards being adopted by MNCs, and do these standards constitute a novel and effective approach to improving the environmental performance of industry?

The chapter addresses the issue of global standards and the environment from the perspective of recent research within economic geography on issues of economic globalization. We take this starting point precisely because much of the recent interest in global environmental standards among politicians and policy makers is a reaction to economic globalization and to the likely environmental and social consequences of intensified flows of capital, technology, and information on a global scale. The growing force of neoliberal trade and investment regimes, and the rapid growth in foreign direct investment and international trade within the world economy, has led many to call for a new global governance of economic processes that will ensure more positive development outcomes (Rodrik *et al.* 2002; UNDP 2003). What Rodrik and others have in mind in this regard is some combination of supra-national institutional capability and strengthened state-based regulation to match the growing global reach of MNCs. What then are we to

make of the adoption of firm-based global standards? Are such standards an effort to head off state-based regulation, as neo-liberal critics might suggest (see, e.g. Peck and Tickell 2002), or are they a response to a need to find new ways to manage complex, global production networks?

Notwithstanding the rich body of theoretical and empirical work within economic geography on issues of economic globalization (see e.g. Dicken 2000; Dicken *et al.* 2001; Scott 1998), and on multinational firms and global production networks, there have been only a handful of attempts to extend this geographical literature to the study of environmental outcomes (Bridge 2002). Most work within economic geography remains squarely focused on economic competitiveness, growth, and employment as the key performance outcomes to be examined. The current chapter seeks to extend work on the geography of economic globalization to include analysis of environmental outcomes. One of the hallmarks of recent work within economic geography has been the analysis of firms and production networks 'on the ground' through in-depth case studies and survey-based research. Such theoretically informed and empirically grounded research is especially useful in analyzing the actual effects of new institutional arrangements as distinguished from the ascribed motivations behind institutional innovation.

Initial research on the links between economic globalization and environmental standards focused on a particular concern, namely, a hypothesized 'race to the bottom' among manufacturing firms. Increased mobility of capital and support for foreign direct investment, it was claimed, would lead firms to locate pollution-intensive activities in countries with weak environmental regulation. By this account, global environmental standards were required to prevent the creation of pollution havens within developing economies seeking to attract increased foreign investment. As it turns out, the majority of studies conducted to date have found little support for the 'pollution havens' hypothesis. Grossman and Krueger (1993), Leonard (1988), Low and Yeats (1992), and Tobey (1990) all concluded there was little empirical support for the claim that the intensity of environmental regulation impacted patterns of trade, or the location of industries. Similarly, a recent study by Eskeland and Harrison (2003) concluded that abatement costs in OECD countries were not a significant driver of investment in four developing economies.

Part of the difficulty with the pollution haven hypothesis is that it captures only one aspect of the relationship between economic globalization and the environment—the so-called composition effect whereby the environment is impacted by changing patterns of trade across countries. Economic globalization also impacts environmental performance and quality through two other related effects, namely, the scale effects of growth, and the intensity effects of changes in environmental impact per unit of output (Repellin-Hill 1999). The scale effect hypothesizes that trade and investment liberalization result in higher rates of economic growth (Frankel and Romer 1999), and

through this growth increased use of resources, pollution, and other impacts on the environment. The intensity effect hypothesizes that liberalization impacts the intensity of environmental impact per unit of output (e.g. energy use per unit of production) or in some formulations the rate of adoption of technologies that are less pollution and energy intensive. Because scale, composition, and intensity effects can have countervailing impacts on the environment (e.g. the scale effects of growth can be offset by reductions in environmental intensity), it is important to consider all three aspects in terms of economic globalization, standards, and environmental performance.

Several studies are of particular importance in this regard. Hettige *et al.* (1997) studied the impact of trade liberalization on water pollution in 12 countries, finding that scale effects led to an increase in emissions that was only partially offset by an intensity effect. On the other hand, in a study of water pollution in China, Dean (2002) finds that whereas trade liberalization hurts the environment through composition effects, income growth is correlated with reduced environmental impact, and the net effect of trade liberalization is actually positive for the environment. Copeland and Taylor (2003) conclude that the intensity effects of trade liberalization exceed scale and composition effects resulting in improved environmental performance, at least for SO_2. Eskeland and Harrison (2003) find that foreign-owned firms in developing countries tend to use less energy than comparable domestically owned firms. These results are explained in terms of intensified trade and foreign investment providing a conduit for the more rapid adoption of technologies that are less energy, materials, and pollution intensive.

These findings create the context for the work presented in this chapter. If trade and investment liberalization is sometimes associated with positive environmental outcomes through reductions in environmental intensities, can the adoption of firm-based global environmental standards by multinational firms provide a mechanism for intensifying these positive effects? Arguably, if multinational firms were to 'optimize upward' toward an internal environmental standard, rather than normalize downward toward minimum regulatory standards, the adoption of global firm-based standards could generate significant progress in raising environmental performance. The net effect on environmental quality would still depend on the joint impact of scale, composition, and intensity effects, to which firm-based global standards only partially respond.

The central research question to be examined, in sum, is whether the adoption of firm-based global standards for environmental performance can strengthen tendencies toward improvement in environmental intensities of output within manufacturing firms. In the current chapter we reiterate the primary results of the two case studies of the previous two chapters which focus on the adoption of firm-based global standards by MNCs, and the impact of these standards on environmental performance. The chapter begins by reviewing the circumstances surrounding the growing interest in firm-based

approaches to global standards. We then present the main evidence from the two case studies, one involving a cement plant in Thailand partially owned by a European-based building conglomerate, and the other an electronic component facility in Malaysia operated by a US-based MNC. The two case studies illustrate how the contemporary economic geographies of MNCs make the issue of global standards far more complicated than is implied by traditional concepts of a transfer of best practice from 'core' locations within the OECD to plants in developing economies.

8.2 Global Environmental Standards: From State- to Firm-Centered Approaches

Interest in state-centered global environmental standards originates not in contemporary processes of economic globalization, but in the character of certain types of environmental problems that elude effective response at the national scale. Three types of environmental problems are commonly recognized as requiring coordinated international response: transboundary environmental problems (such as acid rain passing from one country to another), global environmental problems (such as ozone depletion and global climate change), and problems of the global commons (such as the preservation of stocks of fisheries and biodiversity). As a response to these three types of environmental problems, countries have entered into literally hundreds of international environmental agreements, many of which involve global environmental standards. From the Convention on Biological Diversity, to the Kyoto Protocol to the United Nations Framework Convention on Climate Change, to the Convention on Long Range Transboundary Air Pollution, these conventions seek to regulate environmental outcomes on an international and sometimes a global scale. Perhaps the most celebrated of these agreements to date is the Montreal Protocol on Substances that Deplete the Ozone Layer. This convention, which entered into force in 1989 and now has more than 180 countries as signatories, is credited with successfully reducing the use of CFCs and other ozone-depleting substances. Perhaps the most controversial convention is the Kyoto Protocol, which was opened for signature in 1998 and sought (and failed) to obtain comprehensive international agreement on reductions in greenhouse gas emissions.

There is now a large literature examining international agreements among states as an approach to establishing global environmental standards (Young 1997). Two types of difficulties in formulating standards through agreements among states are typically recognized. The first category of difficulty relates to global environmental standards *per se*. The establishment of global environmental standards (at least in terms of standards based on environmental quality) presumes that countries can agree on the value that should be accorded to the environment relative to other societal goals, such as

economic growth or poverty reduction. To the extent that there are trade-offs among these societal goals, countries may 'value' the environment to different degrees, and may wish to set environmental standards at different levels. This type of problem was clearly evident in the negotiations around the Kyoto Protocol (along with the related issue of how the costs and benefits of a particular standard would be assigned to different parties to the Convention). A second type of difficulty relates to the focus on nation states as the parties to international agreements. Put simply, while states may commit to the standards contained in international agreements, this only begs the question of how such standards are to be met, and how compliance is to be secured and monitored. If states lack the capacity (financial, legal, technical, or otherwise) to secure compliance, then international agreements end up being a less than effective approach to implementing global environmental standards. Some have argued that the resolution of both these types of difficulties lies in the creation of a new global environmental organization—akin to the World Trade Organization—that is afforded international authority to set and enforce global environmental standards. The prospects for such a state-centered approach to global governance of the environment appear slim, however, and interest is focused instead on integrating the environment into global trade agreements (Esty and Ivanova 2002).

One alternative to setting up freestanding global environmental standards by international agreement is for states to integrate global environmental standards into international economic agreements, whether on a bilateral or multilateral basis (such as the North American Free Trade Agreement (NAFTA)) or more generally under the auspices of the GATT (General Agreement on Tariffs and Trade) or WTO (Esty 1993). The linking of trade and environment policies is not new. Harmonization of standards internationally to reduce trade distortions was a key part of the original GATT (Stevens 1993). But up until the 1980s the focus of such linkage was on enabling trade rather than promoting environmental improvement (e.g. by setting common reference standards for food that facilitate trade in food products). During the 1980s and 1990s, as a response to concerns expressed over trade and investment liberalization, efforts were made to integrate environmental priorities into trade agreements (a process known as policy integration). In the United States, Congress has required that all bilateral free-trade agreements contain provisions for securing environmental improvement. In many ways, however, efforts to integrate environment and trade policies have fallen foul of the same difficulties experienced by states attempting to establish global standards through international environmental agreements—disputes over the costs and benefits of particular standards, and the capacity to implement and monitor environmental commitments. Both the GATT itself, as well as bilateral and multilateral trade agreements such as NAFTA, are fraught with dispute over the introduction of environmental standards.

Even while these two state-centered approaches to setting global environmental standards have been in play, there has been a dramatic increase in the role of quasi-state and civil society actors in attempting to set global environmental standards. Perhaps the most widely known of these initiatives is the ISO 14000 family of environmental standards. ISO 14000 is a set of global, voluntary environmental standards established under the auspices of the International Organization for Standardization (ISO). Founded in 1947, the ISO is a quasi-state organization representing the national standards institutes of more than 130 countries (Corbett and Kirsh 2000). The ISO first launched the 14000 series of environmental standards in 1996. The key standard, ISO 14001, is an environmental management standard—it defines the characteristics of a certified environmental management system, rather than a specific standard of environmental performance. The ISO (2003) reports that as of the end of 2002, at least 49,462 ISO 14001 certificates had been awarded to firms and other organizations in 118 countries[1]. This represents an increase of 34% over the previous year. The ISO 14001 standard (the other well-known standard is the quality standard ISO 9000) is increasingly being adopted by firms worldwide as a means of indicating externally the adoption of an internal environmental management system. Numerous MNCs have announced their commitment to obtaining ISO 14000 certification for all of their operating facilities worldwide. Ford is reportedly the first MNC to achieve such certification for all of its manufacturing facilities (Moutchnik 2003).

There are now a number of studies of the adoption of ISO 9000 and ISO 14000 standards by industrial firms, and these studies are instructive for the light they shed on why firms adopt internal global management standards (environmental and otherwise). Christmann and Taylor (2001) found that among industrial firms in China, the rate of ISO 14000 certification was higher among plants operated by multinational firms, and among domestically owned plants that were exporting to OECD economies. Similarly, Corbett (2002) in a survey of 5000 firms in nine countries found that firms with high exports tend to adopt ISO standards earlier. Both studies conclude that the pattern of adoption of ISO certification can be explained in part by the pressure exerted by downstream customers through global supply chains (firms in developing countries adopt ISO certification in part in response to customer expectations in OECD economies). In addition, ISO certification requirements are used by MNCs as an efficient way of signaling performance requirements to suppliers.

[1] The ISO does not itself certify firms to ISO 14000 or other standards. Certification is performed by independent organizations.

If the ISO is a quasi-state institution, there are also important efforts under way by civil society organizations to define global environmental standards. As with the ISO 14000 certification, most of these civil society initiatives involve the adoption of voluntary global environmental standards by firms, and most are management standards rather than environmental performance standards *per se*. Illustrative of such civil-society-based approaches to setting global standards is the Global Reporting Initiative (GRI). Founded in 1997 by the Coalition for Socially Responsible Economies (CERES), the GRI was established to define a global standard for environmental and sustainable reporting by firms around the world. While thousands of firms issue environmental reports on their activities, these reports do not follow any common standard or protocol and thus lose utility as a basis for performance comparison and as a driver of environmental performance. The GRI seeks to address this problem by setting a common global standard for environmental reporting. The GRI is of interest in part as an example of so-called 'third generation' environmental policy that seeks to impact the environmental performance of industry not just through direct regulation (first generation environmental policy) or market-based instruments (second generation), but through information disclosure and through consumer and community pressure. The efficacy of such third generation policy tools is in turn related to the growing importance of 'reputational capital' as a resource to be managed by firms.

Both the ISO 14001 and the GRI are voluntary environmental standards that are being adopted by some firms as a global performance standard. This raises the question as to why firms are adopting these voluntary standards, and more generally, why some MNCs are shifting toward the adoption of uniform environmental management standards for production facilities worldwide (firm-based global standards). As indicated above, empirical studies of the rate of adoption of ISO 14001 suggest that this shift to firm-based standards is in part driven by supply chain pressures and as a tool for MNCs to 'qualify' upstream suppliers. But it seems likely that a broader set of processes are at work here related to efforts to reduce transactions costs and enhance profitability within complex multi-plant organizations. Dowell *et al.* (1999) examined the adoption of global environmental standards by a sample of US-based MNCs. The authors found that firms adopting a single, stringent global environmental standard have higher market values, as measured by Tobin's Q, than firms defaulting to less stringent, or poorly enforced host country standards. The authors do not in this study, however, establish the causal basis for this empirical finding (do high performing companies adopt global environmental standards, or do global environmental standards contribute to firm performance, or both?). In order to explore these issues, we turn to two case studies of the adoption of firm-based global standards by MNCs. The case studies are based on a questionnaire survey, followed by lengthy in-plant interviews with the firms (one in Thailand and the other in Malaysia).

8.3 Case Study: Cement Manufacturing Plant in Thailand

Cement represents an interesting industry within which to explore the implementation of firm-based global environmental standards. First, cement is an energy-intensive and pollution-intensive industry that has been identified as a major source of both greenhouse gas emissions and air pollution. The energy consumed by the cement industry is estimated at about 2% of global primary energy consumption, or almost 5% of global industrial energy consumption and 5% of total global CO_2 emissions (Hendriks *et al.* 1998). While dust is the major air pollutant in the industry, there are also important toxic concerns related to the use of recycled materials as an alternative source of fuel. Ironically, technologies developed to reduce dependence on fossil fuels have given rise to new environmental concerns.

Cement is also entangled in contemporary processes of economic globalization in interesting ways. As a bulky commodity, cement is not predominantly an export-oriented industry. It is, however, the focus of substantial international investment and technology transfer. Much of the core kiln technology used by cement plants around the world is manufactured within OECD economies. And there is a large amount of international investment in the cement industry, both in the form of new plant construction and takeovers of existing plants by international investors. The cement industry is dominated by five large multinational firms, each of which operates in upwards of thirty countries (Holcim, Lafarge, Cemex, Heidelberg Zement, and Italcementi). These large firms have bought into formerly domestically owned plants throughout the world, from North America to Latin America, Eastern Europe and Asia.

Several of the larger cement conglomerates have moved to establish a set of global firm-based standards for environmental management, and uniform approaches to management and reporting of energy use and pollution emissions. As these conglomerates have bought into formerly domestically-owned firms, and as the plants are brought under the auspices of the firm's global environmental practice, this creates a 'natural laboratory' for studying the impacts of firm-based standards on environmental performance. Our first case study involves a Thai-based cement firm in which a European-based building conglomerate acquired the largest ownership stake in 1999. Following the Asian economic and fiscal crisis of 1997–8, many of the independent cement firms in Southeast Asia were acquired by foreign firms. By one estimate, foreign ownership of cement capacity in East Asia (outside of China) controlled by multinationals increased from 20% in the mid-1990s to 60% at the end of the decade (*The Economist* June 19, 1999).

One further context for the case study is the 'lumpy' character of capital investment in cement production facilities. Cement production is a kiln-based process in which raw materials are heated to over 2000 degrees. Energy efficiency of the cement kiln is defined in large part by kiln technologies in use

which in turn are closely tied to when a plant was constructed and from where the kiln technologies are sourced. Cement kilns constructed within the last ten years with leading-edge technologies have energy efficiencies that exceed substantially those of older kilns, sometimes by a factor of three. Because many of the cement plants in Thailand (and elsewhere in East Asia) are relatively new, these plants tend to be relatively efficient in energy use (and sometimes in pollution intensity as well).

The case study cement firm in Thailand discussed in great detail in Chapter 5 was founded in the late 1970s and experienced major growth during the 1980s and early 1990s related to the expansion of the Thai economy. The firm operates six cement plants with a total production capacity of approximately 12 million tons of cement per year. The most recent kiln was opened in 1996 and has a production capacity of more than 3 million tons per year. The kiln uses industry-leading technology and achieves energy intensity (kilocalories per ton of clinker) and air pollution emissions (total suspended particulates per ton of clinker) that are among the best in the world. In 1999, a European-based building materials firm acquired a 30% interest in the Thai case study firm, following the collapse of the Thai baht. While our case study covered a number of issues, we focus here specifically on the issue of firm-based global environmental standards.

The European-based firm operates 129 cement plants in more than 30 countries in North America, Europe, Asia, Latin America, and Africa. The MNC maintains various forms of firm-based global environmental standards, ranging from standardized management and reporting practices to performance standards for energy use and emissions. The adoption of firm-wide global environmental standards is relatively new to the MNC; prior to 2000 each cement plant operated fairly independently and environmental performance was managed in a decentralized fashion by individual plants. The conglomerate requires that all of its subsidiary cement plants be ISO 14001 certified by 2004. As of the end of 2002, 20 of the firm's plants were ISO 14001 certified (including our case study plant).

The conglomerate uses a standardized set of economic (e.g. cost per ton of cement) and environmental performance (e.g. CO_2 emissions per ton of cement) metrics that all plants must report around, as well as target air emission guidelines that plants are expected to meet by 2007. The emission guidelines are different for existing and new plants, reflecting the impact of age of capital stock on environmental performance as described above. The conglomerate reports performance for these standards metrics for all plants, allowing individual plants to compare their performance to any other individual plant, as well as to firm-wide averages, and firm performance targets. The conglomerate requires the use of specific computer-based continuous monitoring equipment to track and record emissions of dust, SO_2, NO_x, volatile organic compounds, periodic measurement of mercury and heavy metals, as well as a specific methodology for calculating emissions. The

conglomerate provides training in the installation and use of the monitoring equipment as needed.

The conglomerate has two other important firm-based global standards, one related to greenhouse gas emissions, and the other to the use of alternative fuels (the latter motivated in part by a desire to reduce primary fossil fuel consumption). The conglomerate as a whole has a stated goal of reducing CO_2 emissions by 2010 to a level 20% below the MNC's baseline emissions in 1990. All plants are required to follow a prescribed methodology to calculate and report CO_2 emissions, to develop a plan for reducing emissions, and for increasing the use of waste materials (typically waste oil, but also rice husks, tires, and other materials) as a source of fuel.

In the case study we examined the impact upon the Thai cement plant of being brought into the firm-based global performance standard. Because the Thai firm was already a leading performer, both economically and environmentally, environmental performance *per se* was not a major source of concern. The case study plant already in 2002 met the 2007 firm-based global standard for dust, SO_2, NO_x, volatile organic compounds, and mercury. The plant was among the lowest cost producers of all of the plants operated by the MNC worldwide, and the highest performer in terms of net operating efficiency. For the Thai plant, meeting firm-based global standards was largely an issue of adopting a set of management practices (with the exception of an alternative fuels program described below). These management practices in turn reinforced a trajectory of environmental improvement that was already in place.

Interviews with plant personnel indicated the following changes in operations that were driven by adoption of the MNC global performance standard. First, the MNC standard led to the introduction of computer-based, real-time monitoring of emissions, along with specific protocols for calculating and reporting air emissions, and greenhouse gas emissions.[2] The plant invested approximately $1 million to meet this monitoring standard. The MNC helped the Thai plant prepare a plan to reduce CO_2 emissions which have to date resulted in a 12% reduction in carbon emissions intensity. Second, because the Thai plant now has access to standardized performance information for other plants operated by the MNC, they are able internally to benchmark their own performance. Third, the MNC introduced a standardized alternative fuels and raw materials program (AFRM), which has resulted in a dramatic increase in the use of alternative fuels and raw materials. Prior to incorporation within the MNC program, the Thai plant lacked expertise and experience in the use of alternative fuels. Fourth, the Thai plant has been able to bid on intra-firm contracts to provide technical assistance to other plants within the MNC network. In 2002 the Thai plant earned over

[2] This computer-based monitoring was not limited to the environment. For example, major changes were made in cost accounting that resulted in significant cost reductions.

$10 million through providing such technical assistance to other plants operated by the parent MNC.

Why did the MNC move to adopt firm-based global environmental standards in the late 1990s? Our case study suggests two primary motivations. First, in the late 1990s the major global cement firms were concerned about the potential adoption of new and stronger forms of state-based regulation, especially eco-taxes based on carbon intensity of energy use, and possibly direct regulation of greenhouse gas emissions. The cement industry launched a ‘sustainable cement’ initiative under the auspices of the World Business Council for Sustainable Development that had at its core a series of voluntary initiatives to reduce emissions, improve energy efficiency, and reduce pollution. Second, the MNC realized that with each additional cement plant acquired, the firm as a whole became vulnerable to bad publicity and the threat of regulation from the poor performance of individual plants. As the firm noted in its 2002 annual report: ‘as we become an integrated group, reputational risks multiply.’ The firm could respond to such risks in multiple ways. Up until the mid-1990s, the normal approach was to make sure that the firm could claim that a particular plant met all local and national environmental standards. Where the risk to the firm of an individual poor performing plant was too great, or where local and national standards could not be met, the firm could sell off that plant (thereby ending the reputational risk to the firm as a whole). Finally, the firm could respond by setting internal global standards and protect its reputational capital through developing plans for all plants to meet a single set of intra-firm standards. The latter approach created transactional efficiencies for the firm, and protected the firm from claims that compliance to low or weak domestic standards was an insufficient response.

What is perhaps most interesting about this particular case is the way in which the implementation of firm-based global environmental standards served not simply as a tool for environmental compliance, but as an approach to performance-based continuous improvement. As anticipated in the literature on information-based environmental performance management, intra-firm benchmarking served as a platform for firm-wide learning (and literally created an intra-firm market-place for technical assistance). The organization and geography of the attendant knowledge flows within the MNC is a far cry from the stereotypical core–satellite model of OECD-based MNCs—much critical information flowed from the acquired plant in developing Asia to MNC headquarters in Europe.

8.4 Case Study of an Electronics Plant in Penang, Malaysia

The second case study involves a wholly owned manufacturing plant in Penang, Malaysia, operated by a large US-based electronics MNC. The plant was opened by the MNC in 1974 as an electronic component assembly

facility. Over time, the facility has added research and development, product design, and manufacturing. Currently the facility manufactures two-way radios and batteries. The Penang plant works with a variety of local and international suppliers, including manufacturers of printed circuit boards, semiconductors, plastics, and the like. The plant has its own environmental health and safety policy, and is also governed by the firm-wide environmental policy which includes both procedural and performance-based global environmental standards. The plant was ISO 14001 certified in 1999. The MNC's attention to firm-based standards intensified during the early 1990s and now covers a wide variety of design and production concerns. Specific operational performance goals and disclosure requirements were introduced in the mid-1990s.

The global firm-based environmental standards of the MNC fall into three main categories: performance, procedures, and suppliers. With respect to operational performance, the MNC has firm-wide goals for reducing emissions of volatile organic compounds (by 10% a year), hazardous air emissions (10% per year), PFCs (reduce 50% from 1995 levels by 2010), hazardous waste (reduce 10% per year), water use (reduce 10% per year), and energy use (reduce by 10% from 1998 levels by 2003). The MNC also has product performance goals related to the design of products that are recyclable, and use less energy and hazardous materials. With respect to procedures, the MNC maintains a series of specific protocols and reporting requirements that must be followed by all plants worldwide. The firm uses various software tools at its plants (two such proprietary firm-based tools are the Green Design Advisor and the Product Environmental Template) that allow comparison of different design alternatives in terms of environmental impacts. In 1993 the MNC introduced an internal audit program for all manufacturing plants. The MNC is also a signatory to the Global Reporting Initiative. With respect to suppliers, the MNC maintains three core global firm-based environmental standards. First, all qualified suppliers must be ISO 14001 certified. Second, suppliers cannot manufacture products for the MNC using ozone-depleting substances. The MNC eliminated the use of CFCs from its own manufacturing processes worldwide in 1992. Third, suppliers must complete materials disclosure sheets for all goods supplied. These sheets detail the use of specific named materials (e.g. lead and heavy metals) in components supplied to the MNC and are a key tool in monitoring overall product design.

As in the previous case study, the MNC benchmarks individual plants against the firm-wide operational and product performance standards. The Penang plant is benchmarked on such performance measures as water use (liters per person hour), electricity usage (KW per product unit), hazardous waste (thousands of metric tons per billion dollars of sales), waste recycling (percentage recycled) using a computerized reporting and tracking system. The MNC uses a worldwide environmental data management tool that lists

hazardous materials used in all component parts of all MNC products (driven by the supplier materials disclosure system described above). Our case study plant noted that these firm-based global standards have resulted in substantial improvements in environmental performance, both firm-wide and in this particular plant. For example, firm-wide the MNC has over the past four years reduced the use of volatile organic compounds by 55%, reduced energy consumption by 14%, and reduced water usage (through recycled use of waste water and other means) by 41%. Our case study plant cited as examples of their own performance improvement a 75% reduction in the use of hazardous materials (per unit built), and reductions in water use from 35 liters per person hour in 2000 to 15 liters per person hour in 2003.

Perhaps the most interesting aspect of the global firm-based standard in use at this case study plant relates to commitments to reduce the use of lead and other metal toxics in both products and production processes. As indicated, the MNC has a firm-wide goal of reducing the use of hazardous materials and designing products in ways such that any remaining hazardous materials can be recaptured in recycling. Much of this is driven by recent legislation in Western Europe and pending legislation in China and California. The European Waste in Electrical and Electronic Equipment Directive (WEEE) became law in February 2003 and sets standards for recycling of electrical products. The Reduction of Hazardous Substances Directive (RoHS) bans the use of heavy metals in the manufacture of electronic equipment. To meet these regulatory requirements, the MNC is breaking down every product, and every constituent part, in terms of metals used (on a parts per million by weight basis). Because much of the metal content is contained in component parts, and in the manufacture of component parts, the EU legislation has been a major driver to extend the MNC's firm-based standards to first tier (qualified) suppliers, and through these suppliers to their sub-suppliers.

As indicated above, the key to implementing the firm-based global standard on recycling and use of hazardous waste is the mandatory materials disclosure form. All first tier suppliers must submit this form for every product supplied, and first tier suppliers are required to cascade the reporting requirement to their sub-tier suppliers. Suppliers must report on both 'controlled substances' and 'reportable substances'. Controlled substances are substances that are either banned from electronic products, or where a ban or voluntary phase-out is anticipated (e.g. lead, CFCs, cadmium, and PCBs). Reportable substances are materials whose use the MNC seeks to reduce through eco-design (e.g. copper, PVC, and tin). Based on this reporting system, the MNC is able to calculate for all final products the use of controlled and reportable substances on a parts-per-million by weight basis. Where substances are controlled, or use exceeds the firm-based maximum limit, the MNC works collaboratively with the supplier to eliminate or reduce the use of that material. At our case study plant, the initial priority was to design products and production processes that are lead and halogen

free (controlled substances). One of the first tasks was to design a lead-free soldering paste (developed jointly with a US-based supplier). This was a firm-wide initiative that involved multiple parts of the MNC. The firm is now working on a replacement for a PCB material that uses lead as a stabilizer. The consequence of this system of data reporting and product design is that the MNC's global performance standard has dramatic reach into the operations of component suppliers.

8.5 Conclusions

Perhaps the most striking feature of the case studies is the level and range of environmental improvement currently under way at the two plants. The documented reductions in energy, materials, and pollution intensities of product and production processes is substantial, and in many instances large enough to offset the scale effects of increased production, resulting in net improvements in the impact on the environment. These are far more than minor, incremental improvements in environmental intensity and for this reason deserve the attention of policy makers, as well as careful analysis by the research community that goes beyond the case studies presented in this paper. Having said this, it is important to note that the plant-level analysis and the firm-based global standards do not capture the full environmental effects of the production systems under study.

At least at the two case study plants, the pace of this environmental improvement intensified from the mid-1990s onward, and this coincided in time with the implementation of global firm-based environmental standards at the two plants. The critical question is to what degree global firm-based standards were responsible for this improvement. Preliminarily we conclude that whereas the primary drivers of environmental improvement remain external to the firm (e.g. in national and international environmental regulations), firm-based standards have emerged as a key tool for finding ways to improve environmental performance. Stated another way, at our two case study plants firm-based standards are more a platform for firm-based learning and innovation than they are a driver of compliance. This suggests that future research focus on standards, and all of the performance measurement and analysis that goes with it, in terms of the types of intra-firm innovation that is enabled by this approach to environmental management.

The two plants selected for case study in this research are both located in Southeast Asia, a region that is at the leading edge of contemporary processes of economic globalization. In the case of the Thai cement plant, the connection to the global economy has primarily involved equipment purchases and technical support from OECD suppliers, and then subsequently foreign direct investment and incorporation into the operations of a large MNC. In the case of the Malaysian electronics plant, the global connections

were present from the start, as the plant was established as a branch facility of a US-based MNC during the earliest phase of manufacturing FDI in one of the tax-free zones in Penang. In addition, from the beginning the products manufactured at the plant were destined for export, primarily to OECD countries, and for this reason the plant was well attuned to the expectations of foreign markets (including regulatory standards in those markets). One consequence of this integration into the global economy is that even prior to the implementation of global firm-based standards in the 1990s, both plants were actively engaged in a process of global scanning to identify and implement ways to improve quality, and economic and environmental performance. Both plants were thoroughly part of a global 'learning environment' that as often as not stretched beyond the firm to external customers, suppliers, and competitors. The difference made by global firm-based standards was to strengthen the space of learning beyond the individual plant but internal to the firm.

Both of the firms in the case study have strong internal environmental management systems and seek out and respond to industry-wide best practice in environmental performance. It is worth noting in this regard that Malaysia and Thailand have quite different approaches to, and capabilities for, environmental regulation of industrial firms. Environmental regulation in Malaysia is based on a rigorous system of ambient standards, plant-level monitoring and inspection, and fees and fines for non-compliance (Rock 2002*a*). While Thailand also has a strong legal framework for environmental regulation, monitoring and inspection of industrial plants is far more limited and often depends on voluntary reporting of environmental performance by firms (Rock 2002*a*). In this context of a relatively weak regime of regulatory inspection and enforcement, the excellent environmental performance of the Thai cement plant is an indication of the effectiveness of the internal environmental management system of the firm. The introduction of firm-based global standards served to strengthen further this existing strong environmental management system. Clearly, this combination of an under-resourced national environmental regulatory system and a strong internal environmental management system offers one of the best opportunities to leverage firm-based global standards toward environmental improvement.

As we conducted our case study interviews, it became very clear that global standards *per se* were just one part of a broader information-based and performance-driven approach to environmental management at the plants. Where the global standards made a difference was in creating a broader platform for learning, information exchange, and innovation. Global standards have allowed MNCs to mobilize more effectively intra-firm learning, and to the extent that these standards extend to suppliers, learning within supply chain networks as well. Inter-plant, but intra-firm, performance comparisons quickly lead to questions as to how one plant achieves a higher level of performance, and whether the approach taken or the technology used

in one place can be adapted and adopted at another location. The organization and geography of this intra-firm learning and information flow is quite complex and in some cases bypasses the firm headquarters altogether. The degree to which our two case study plants, located in developing East Asia, have become sources of innovation for the firm as a whole is quite striking.

For our two case study plants, ISO 14001 is but a preliminary step toward what is now a very extensive internal environmental management system. Indeed, it is already becoming apparent that ISO 14001 as a tool for promoting environmental improvement is likely to be of greatest use to small and medium sized enterprises that lack strong internal environmental management systems. We also observed in our case study evidence of firm-based standards impacting the environmental performance of suppliers, including a number of relatively small local enterprises. We end on a note of caution in this regard. The tendency on the part of many MNCs to restrict the use of suppliers to a small set of qualified firms (see Felker 2003), is likely to have a major negative impact on the ability of small and medium sized firms in developing countries to engage in technological learning and upgrading through participation in global production networks. Thus at a time when global firm-based standards are reaching into supply networks, these supply networks are becoming more constrained, narrowing the opportunities for learning and upgrading by emerging small and medium sized enterprises.

9

Implications for Other Industrializing Economies

9.1 Introduction

In previous chapters we have demonstrated how the practice of policy integration—the linking of environmental regulatory policies with resource pricing policies, trade and investment policies, and technological capabilities building policies—in the East Asian NIEs has driven down the energy and pollution intensity of industrial activity in these economies. As we have shown, each East Asian NIE used a somewhat different strategy for driving down environmental intensities. Singapore did it by effectively linking its tough environmental agency, the Ministry of the Environment, to the country's premier institutions of industrial policy—the Economic Development Board and the Jurong Town Corporation—charged with attracting OECD multinationals and providing them with factories and OECD-like infrastructure facilities. Taiwan Province of China took a decidedly different path. Following the decision of the central government to create a tough regulatory agency in the face of strong opposition from the country's institutions of industrial policy, the government, by building a capable regulatory agency and allowing it to get tough with polluters, demonstrated to those who managed the institutions of industrial policy that they would have to adapt to a crackdown on polluters. They did so by using the institutions of industrial policy to craft an approach to industrial environmental improvement that linked Taiwanese firms and the Taiwan Environmental Protection Administration to the technology-upgrading policies of the Industrial Development Bureau in the Ministry of Economic Affairs and the technological research activities of the Industrial Technology Research Institute.

Where governments had less capable environmental regulatory agencies, they used several other pathways to policy integration. The government of Malaysia followed two different pathways to policy integration. On the one hand, it adopted an industry-specific approach to de-link palm oil production and the export of processed palm oil products from palm oil pollution by integrating palm oil processors with a quasi-public, quasi-private palm oil research institute, the Palm Oil Research Institute of Malaysia, and the Department of the Environment in a search for a cost-effective palm oil

waste treatment technology. Once a viable solution to pollution emerged, the Department of the Environment used its embedded autonomy with producers in this sector to ratchet up emissions standards and de-link palm oil processing from palm oil pollution. On the other hand, the state government of Penang in Malaysia relied on a vendor development program, an industrial linkage program, and a global suppliers program to assist local small and medium sized firms supplying electronics multinationals to technologically upgrade their capabilities to meet the price, quality, and on-time delivery requirements of their multinational customers.

As we will demonstrate (see discussion below), one unintended but beneficial consequence of these multinational small and medium sized linkage programs is that multinational electronics began working with their small and medium sized (SME) suppliers on a host of environmental intensity issues. Thailand and China, with even weaker environmental regulatory agencies and where environmental improvement has been more limited (Rock 2002*a*), have relied on indigenous and large private firm-level environmental improvement programs (Chapter 6) or the corporate-level environmental improvement programs of OECD multinationals linked in joint ventures to large local firms (see the discussion of Thailand in Chapter 6) or on a novel city-level public disclosure program that effectively linked local government officials charged with industrial development with those charged with environmental improvement (see the discussion of China in Chapter 3).

In this chapter we take up the question of whether policy integration has relevance beyond the examples of the East Asian NIEs that have been the empirical focus of this book. Because policy integration looks so different in each East Asian NIE and because governments there appear to have stronger bureaucratic capabilities than their counterparts in the rest of the industrializing world, it would be easy to conclude that the rest have little to learn from the East Asian NIEs' experiences with policy integration. We do not believe this to be the case. However, in identifying the ways in which policy integration might be implemented in other industrializing economies it is important that we disentangle those elements of the approach that are closely tied to the particular political economy of the East Asian NIEs from a more general model of policy integration. In this chapter we make the argument that policy integration in other industrializing countries is likely to be less government centered and more market centered in its orientation.[1] It is also more likely to draw more heavily upon technological learning occurring within supply chains and inter-firm networks. In effect, we are suggesting that as policy integration transitions from the particular form it took during a formative

[1] The analysis here focuses on policy integration in other industrializing economies. In the subsequent and final chapter we consider the prospects for policy integration in very low income countries that as yet have had limited success in pursuing a pathway of technological upgrading and industrial capability building.

period in East Asia to a more mature policy approach, it is likely to shift from being state centered to being more market centered in its orientation. It should come as little surprise that this transition parallels some of the changes under way in the activities of economic development agencies in East Asia from an initial emphasis upon supply-driven policies toward more market-demand-oriented and demand-creating policy frameworks.

9.2 Industrial Capability Building Beyond the First Tier NIEs

What is known about capabilities building policies and institutions that rely less on governments and more on markets? To begin with, policy integration worked in the East Asian NIEs because governments there built a set of institutions or what Justman and Teubel (1995) label technological infrastructure and technological infrastructure policies to support technological and environmental upgrading. While each of the countries in East Asia followed different industrial pathways, all built similar technology infrastructures (Justman and Teubel 1995)—consisting of investment promotion agencies, industrial estate and export-processing zone authorities, export-marketing institutions, national standards/metrology agencies, science and technology institutes, and environmental regulatory agencies.

Despite the relative success of most of the public sector technology support institutions in the East Asian NIEs, attempts to replicate this strategy have not fared well in all of the other Asian NIEs (Rock 1984, 1992), nor in many other industrializing economies. It is now evident that part of the reason for failure relates to the degree to which governments underestimated the degree to which at least some of these services were provided by markets and overestimated the degree to which public sector support institutions could successfully provide such services. In a number of instances, public sector support institutions were built without reference to either countries' overall policy frameworks or their industrial and/or environmental development strategies. When the policy framework undermined incentives for technological or environmental upgrading activities or when governments failed to develop coherent industrial development and/or environmental improvement strategies, demand for the services of public sector support institutions languished.

To make matters worse, many governments frequently under-funded support institutions and failed to require them to develop embedded autonomy with private sector clients. When public sector support institutions were under-funded, they not only failed to develop embedded autonomy with the private sector, but also tended to offer low quality services that frequently failed to meet the real needs of private sector clients. This made it difficult for them to charge for their services and their inability to recover at least part of their costs reinforced the poor quality of service provision.

Because of these failures, it is clear that any initiative to build technological capabilities in other industrializing economies must be part of a coherent national strategy of industrial development, driven by market-building considerations. This is particularly true for the low-income countries where governments and public sector bureaucracies are generally less effective and more prone to weak governance than their counterparts in the East Asian NIEs. The recent experience of industrializing economies attempting to engage in the kinds of rapid industrial capability building achieved by the East Asian NIEs has led to a model of upgrading that is more market focused than was the case during the 1970s and 1980s in East Asia. As we indicated in Chapter 2, even within the East Asian NIEs, the emphasis is now more upon demand-increasing policies than upon supply-driven initiatives. This shift has been reinforced by the terms of the WTO that severely limit the use of industrial promotion activities that are limited to indigenous firms.

Within this more demand-increasing orientation to industrial capability building, firms and industrial networks become primary sources for know-how and knowledge transfer. There is a rich literature demonstrating that firms in several of the East Asian NIEs acquired much of their marketing and technology know-how from their developed country buyers and suppliers (Rhee *et al.* 1984). For example, it is well known that international buyers (importers, wholesalers, and retailers) from developed countries provided substantial technical and marketing assistance to their developing country suppliers in East Asia in a wide range of simple consumer goods (particularly ready-made garments, shoes, and leather goods but also in agro-processing activities) (Egan and Mody 1992). Those buyers were frequently one of the first points of contact between domestic producers and the international market. As Egan and Mody (1992) have demonstrated, international buyers in simple consumer goods were willing to invest in building long-term relationships with their developing country suppliers to reduce their risks and transactions costs. They did so by providing information about and access to international markets, by providing information on product design and technology, and by training their developing country suppliers to meet their price, quality, and on-time delivery specifications. As Egan and Mody (1992) also demonstrate, those long-term collaborative relationships often served as an essential source of information about markets and technology.

Foreign firms and international capital goods suppliers also tended to be the dominant source of new technology and they provided substantial assistance to help local firms adapt new technologies to local conditions (Rhee *et al.* 1984). Since the mid-1980s, East Asian NIE firms have been playing a similar role by intermediating between developed country buyers and capital goods suppliers and other developing country suppliers. The more recent shift by multinationals to international production networks as a vehicle for managing global production and distribution adds yet another element to the

evolving relationships between developing country suppliers and their buyers and technology suppliers in developed countries.

It is in short on the basis of these types of more market-based industrial capability building initiatives that policy integration initiatives are likely to be pursued in other industrializing economies. Of the variety of pathways through which such industrial capability building occurs, the strongest evidence for success in extending the model to a broader array of industrializing economies comes from recent work on environmental improvements achieved within the supply chains of global manufacturing firms. It is to this issue that we now turn.

9.3 Supply Chains as a Pathway for Policy Integration in Industrializing Economies

There is a growing body of work (see Rock 2002*a*; Chapter 7) suggesting that an approach to policy integration that is focused on environmental improvement in global supply chains has wide relevance for industrializing economies in East Asia and beyond. Some of the strongest evidence for this can be found in the Malaysian state of Penang where the state government pursued technological capabilities building by ultimately, and somewhat belatedly, adopting policies that linked local small and medium sized (SME) firms to the global value chains of multinationals.

The Penang government's most important SME–MNC linkage programs include a vendor development program, an industrial linkage program, and a global supplier program. The vendor development program encourages multinationals and large local firms to provide procurement contracts and technical assistance to suppliers who are then eligible for subsidized finance.[2] The industrial linkage program is a cluster-based industrial development program designed to shift the industrial base toward high value-added activities, reduce both the import content and reliance on foreign-based R&D and technology service providers.[3] The global supplier program (GSP) invests in training SME personnel in the important skills necessary for them to become first tier global suppliers to multinationals.[4]

[2] See Felker (1999). Currently, 256 vendors participate in the VDP (vendor development program) of which 25% are from the electronics and electrical goods industries. Eighty-two anchor (MNCs) companies and 16 banks/financial institutions are also involved in the program.

[3] The vendors under the industrial linkage program (ILP) supply parts, components, and related services, along the value-added chain of the leading companies. Priority sectors include transportation, electronics, machinery and equipment, and resource-based industries. The ILP is supported by programs that emphasize SME technology development, technology acquisition, skill enhancement and upgrading, and export market development.

[4] The GSP was launched in 1999 and was designed as a response to the challenges and opportunities arising from globalization. The program aims to enhance the capabilities of

Interestingly enough, none of these linkage programs was or is explicitly concerned with improving the environmental performance of affected SMEs (Lim 2004). Yet despite this, in interviews conducted with a local research partner in Penang, we find that an increasing number of MNCs and SMEs in Penang are concerned about a range of environmental issues (Lim 2004). Most of the managers of the multinationals we interviewed said that their facility in Penang had written environmental policies that extended to their subsidiaries in Penang. These written policies are most frequently part of corporate-wide EHS and sustainability policies that require affiliates all over the world to meet national environmental regulations, go beyond compliance, and seek continual environmental improvement. These written policies tend to be backed up by corporate and Penang facility-specific quantitative environmental performance goals that range from explicit targets for reduction in usage of water and electricity, to restrictions on use of particular hazardous substances, to recycling and reduction in waste. As stated by those managers in the multinationals that were interviewed, meeting these corporate-wide and their own facility-specific goals made it necessary for them to work with their suppliers, particularly on the phasing out of particular hazardous substances, such as the use of lead in solder paste used in printed wiring boards.

As we noted in our detailed case study of Motorola-Penang (Chapter 7), these corporate policies have been reinforced by two impending environmental market requirements for electronic and electrical (E&E) products imported into the European Union (EU). The first, the EU's Waste in Electrical and Electronic Equipment Initiative or WEEE Initiative requires that 75% of any E&E product must be recyclable while 65% of it must be recovered. The second, the EU's Reduction of Hazardous Substances or RoHS Directive sets very stringent limits on the amount of hazardous wastes that can be embedded in electrical and electronics products. As our interviews and the case study in Chapter 7 demonstrated, MNC affiliates in Penang, such as Motorola-Penang, draw on a suite of environmental tools to assess the degree to which its current products and its products under development meet these directives.

The MNC managers interviewed in Penang also recognized that they could not assess the degree to which their products complied with the EU's environmental requirements without extending their environmental practices to their global suppliers, including their global suppliers in Penang. Because of this, the MNCs in Penang are requiring at least their first tier suppliers to

Malaysian enterprises so they can become first tier global suppliers to multinationals in the world economy. It is the culmination of the government's efforts to enhance industrial linkages in SME development. As of the end of 2002, a total of 1,392 employees from 357 SMEs have undergone training under the GSP program while eight SMEs under the linkage initiative have been adopted by eight MNCs to be promoted as first tier global suppliers.

develop their own written environmental policies with specific continuous environmental improvement goals and they are requiring these suppliers to become ISO 14001 certified. Beyond that, the MNCs require their suppliers to eliminate CFCs and other ozone-depleting substances from their production processes. They also require their suppliers to complete detailed materials disclosure sheets for all goods supplied. At Motorola-Penang, these sheets identify the use of specific-named materials, for example, lead and all heavy metals, in components supplied, the amount of those materials embedded in each part supplied, and, not surprisingly, the information provided in these data sheets are used in monitoring the conformity of new products with the EU's RoHS Directive.

But work with local SME suppliers extends well beyond requests for additional information and testing of supplied parts or commodities. Increasingly, the MNCs in Penang have been forced to work closely with suppliers and dealers on numerous environmental problems related to increasing the compliance rate of their products with RoHS and WEEE. Again, this can best be demonstrated by the case study of Motorola-Penang. As noted in Chapter 7, in one instance, Motorola-Penang worked very closely with several chemical suppliers,[5] other subsidiaries, and corporate headquarters to develop a new no-clean flux tin/lead (essentially lead-free) solder paste. All the information developed as a result was shared with the suppliers of the new product. A similar process was used in developing halogen-free printed wiring boards (PWBs) and flexible wiring boards (FLEX).[6] In this instance Motorola Inc. and its subsidiaries, including its subsidiary in Penang, worked with both PWBs and FLEX manufacturers and their raw material suppliers to reduce the amount of halogen in PWBs and FLEX. Following the successful adoption of lead-free and halogen-free raw materials for the manufacture of PWBs and FLEX, Motorola-Penang worked with key dealers and repair shops, both of whom raised questions about both the reliability of the new products and how to repair them. Subsequently, the MNC produced a new internal technical manual for these new products that detailed the new specifications and the problems associated with them.

Interviews with SME suppliers to the major electronics multinationals in Penang revealed that SME managers have grudgingly come to recognize that their ability to meet the environmental requirements of their buyers is just another requirement, like the price, quality, and on-time delivery requirements, that they must meet to remain or become first tier suppliers to the

[5] One supplier was a United States-based supplier, while another was a Malaysian supplier.

[6] FLEX refers to flexible wiring 'boards'. FLEX is used in numerous, particularly small, electronics products such as cell phones.

MNCs. What this suggests is that at least some of the MNCs and SMEs in Penang are learning how to leverage the environmental support services provided by international markets.

This set of findings from our interviews in Penang led us to formally test the hypothesis that electronics MNCs and SMEs in Penang were leveraging the environmental support services provided by international markets by working together on numerous environmental issues. We did so by using the results of our survey interviews of an admittedly small sample of 13 electronics MNCs in Penang to estimate the following ordinary least squares regression equation.

$$ENVHELP_i = \mathrm{a}_0 + \mathrm{a}_1\, NLSPOE_i + \mathrm{a}_2\, EXPORTS_i + \mathrm{a}_3\, SSCHAINPEQG_i + \varepsilon_i$$

$ENVHELP_i$ is a measure of the degree to which the *i*th electronics MNC provides environmental assistance to its local suppliers. *ENVHELP* is a composite variable that sums the responses to four questions asked of MNCs about their environmental supply chain practices. The questions we asked are: do your supply-chain management practices in Penang include (Yes = 1, No = 0) helping suppliers to develop an environmental management system (EMS); training suppliers in good EMS practices; demonstrating to suppliers how they can protect storm drains from their waste stream; and helping suppliers to reduce their wastes? $NLSPOE_i$ is the number of local suppliers a MNC has in Penang standardized by the number of direct employees the MNC has in Penang.[7] Our hypothesis is that as the relative importance of local suppliers to local employment rises, MNCs become more concerned about the environmental practices of their suppliers and they respond to this by providing more environmental assistance to suppliers. $EXPORTS_i$ is the share of production exported by the *i*th MNC. Our hypothesis is that environmental assistance to suppliers increases with the share of output exported. $SSCHAINPEQG_i$ is a dummy variable, $SSCHAINPEQG_i = 1$ if the *i*th MNC has an environmental supply chain program in Penang with quantitative environmental improvement goals and $SSCHAINPEQG_i = 0$ otherwise. We expect $SSCHAINPEQG_i$ to positively impact $ENVHELP_i$. Estimation is by ordinary least squares with White's heteroskedasticity-consistent standard errors and results appear in Table 9.1. All variables are statistically significant with the expected signs, the equation is statistically significant at the 0.01 level, and the three independent variables account for more than 90% of the variation in the extent of MNCs'

[7] $NLSPOE_i$ is defined as the number of local suppliers divided by the number of direct employees who work for the *i*th MNC. $NLSPOE_i$ is a measure of the importance or density of the *i*th MNC's local supply chain.

TABLE 9.1. Regression equation on electronics multinationals

Environmental assistance to their local suppliers (*ENVHELP*)			
Independent variables	Regression coefficient	Standard error	*t* statistic
Constant	−10.10		
NLSPOE	9.98	3.177	3.14**
EXPORT	0.10	0.05	1.99*
SSCHAINPEQG	1.27	0.05	2.99**
$\bar{R}^2$	0.92		
Equation *F* statistic	33.62***		
N	10		

Note: *** indicates statistically significant at the 0.01 level. ** indicates statistically significant at the 0.05 level. * indicates statistically significant at the 0.10 level.

environmental assistance to suppliers. From these results, it appears that at least some of the electronics MNCs in Penang are working closely with their SME suppliers in Penang on a host of environmental issues. In addition, several of the local SME managers we interviewed said that they had actively sought out the assistance of their MNC customers so they could leverage the environmental support services provided by international markets. They were doing so because both the multinationals and markets they served required this of them.

Because of the increased reliance of MNCs on global or international production networks, we believe this trend is likely to provide important opportunities for governments in other industrializing economies to assist firms in this market leveraging strategy. Among other things, governments in these economies can assist in the expansion of high-quality, world-class ISO certification capabilities. A leveraging strategy, at least as practiced in Penang, also suggests what government interventions might forgo. Chief among these appears to be pollution prevention or clean production programs embedded in government agencies de-linked from SME–MNC linkage programs and the real world environmental problems faced by SMEs. The government of Malaysia, like numerous other governments in the rest,[8] has created multiple donor-funded clean production or pollution prevention programs. There is no evidence that these programs work in Malaysia, nor is there any evidence that they are linked to the leveraging of the environmental support services provided by international markets.

Leveraging is likely to be particularly important for the rest because it reduces the demands on governments and because buyers are usually only

[8] 'The rest' refers to the rest of the developing world as exemplified by Amsden (2003).

willing to transfer the minimal amount of marketing and technical information needed by suppliers to meet their specifications. The former is a critical consideration when governments are weak, unstable, and/or prone to corruption and rent seeking, as they tend to be in the rest. The latter is important because it suggests that unless governments and firms make a serious effort to maintain good relationships between international buyers and their suppliers in developing countries, the latter can become trapped in low value-added activities. Governments in the rest can also adopt leveraging policies by assisting local firms through match-making services linking buyers to suppliers, by helping local suppliers piece together missing elements in international information channels, and by assisting local suppliers, through vehicles such as formal linkage programs between local firms and MNCs, in aggressively securing the most out of their long-term relationships with buyers.

9.4 Conclusion

The central message of this chapter is simple and powerful. To begin with, we argued that other industrializing economies beyond the East Asian NIEs can successfully practice policy integration. But because governments in the rest of the industrializing economies tend to have less capable government bureaucracies than their counterparts in the East Asian NIEs, we suspect that successful practice of policy integration in other industrializing economies is most likely to occur when governments adopt approaches to policy integration that economize on limited government capabilities by leveraging the opportunities for technological upgrading and environmental improvement created by international markets. The evidence presented in this chapter suggests there are two possible ways to do this. One is by adopting an upgrading and environmental improvement strategy based on linking local small and medium sized firms to the global value chains of OECD multinationals. This approach to upgrading and environmental improvement relies heavily on leveraging international market pressures for upgrading and for environmental improvement. In this instance, policy integration can follow from the participation of small and medium sized firms in the global value chains of OECD multinationals. But as our Malaysia case study and survey data show, the effectiveness of this leveraging strategy depends on governments developing effective vendor development programs which link SMEs to OECD multinationals. The other possible approach to policy integration requires governments to adopt a large firm upgrading and environmental improvement program, one that links support for large local firms to the global economy and OECD multinationals. This strategy also depends on leveraging international market pressures for upgrading and for environmental improvement. As the evidence (see Chapters 2, 5, 6) on this strategy

shows, because it is subject to rent-seeking and corruption between promoted firms and high ranking government officials, this approach to policy integration is a bit more difficult for governments than a strategy based on linking SMEs to the global value chains of OECD MNCs.

10

Prospects for Policy Integration in Low Income Economies

10.1 Introduction

In the final chapter of the book, we turn to the question of the prospects for policy integration in the low income countries, or the poorest of the rest of the industrializing economies in Africa, Asia, and elsewhere.[1] Is there any evidence that these low income countries can or have practiced policy integration? Does policy integration offer opportunities for low income countries to pursue industry-led growth strategies in ways that balance concerns with the environment and those of poverty reduction? Answering these questions is a difficult challenge in that far less is known about the institutions and strategies of industrial capabilities building in low income countries than is known about industrial capabilities building in the East Asian NIEs. To partially address this concern, we have conducted a questionnaire survey of the effectiveness of industrial capability building strategies and institutions in a sample of 27 low income countries in Asia, Africa, Latin America and the Caribbean, and in the former Soviet Union. We then combine these survey data with the published measures on country industrial competitiveness and on macro-institutional conditions, as used in Chapter 2, to provide an initial assessment of the effectiveness of industrial capability building strategies in these countries, as well as the macro- and meso-level institutional obstacles to effective policy integration.

Building on the analyses of industrial upgrading presented in Chapter 2 and of policy integration in Chapter 3, we need to consider three broad domains of institutional effectiveness. First, we need to examine the extent to which the basic enabling conditions identified in Chapter 2 are, or are not, being met in low income countries. In Chapter 2 we argued that openness to trade and investment, macroeconomic stability, political stability, development of a substantial physical and human infrastructure base, and bureaucratic capability in government are critical to industrial competitiveness and

[1] The poorest of the rest are all those developing countries in the World Bank's low income category, that is, those who GDP per capita in 2002 was below $3,000 PPP (in constant 1995 dollars) (World Bank 2004).

industrial capability building. These variables, along with better resource pricing policies and the development of an effective environmental regulatory agency embedded in the institutions of industrial policy, are also critical for improving the environmental performance of industry (Chapters 3 and 9). To examine these conditions, we use the same country-based macro measures of enabling conditions presented in Chapter 2, but focus here on the results for low income countries.

Having considered basic enabling institutions, we then need to look specifically at the institutional framework of industrial capability building and technological catch up in the low income countries. With respect to technology infrastructure and associated policies, five questions must be answered. First, are public sector bureaucracies in the poorest of the rest sufficiently competent to design and implement market-oriented, demand-driven technology policies and institutions? Second, are technology policies and technology support institutions part of a coherent national industrial development strategy? Third, are both sufficiently linked to the international economy and the foreign firms working in their countries? Fourth, do the technology infrastructure and associated policies leverage market-building opportunities, including market-building opportunities for the export of manufactures for technological and environmental upgrading? Finally, are the institutions of technology infrastructure structured to take advantage of one of the three pathways to technological upgrading identified in Chapter 2—that is, through the building of a national innovation system, through the development of large indigenous firms linked to the global economy, or through the participation of local small and medium sized firms in the global value chains of OECD multinationals (see also Bennett 2002)?

Finally, we need to look at issues of policy integration and here another set of questions must be asked about the policies/institutions of industrial environmental improvement in the poorest of the rest. First, do the governments in these economies have credible environmental regulatory agencies with the capabilities to effectively monitor and enforce sensible industrial facility-level emissions standards? Second, do the governments in these economies complement their traditional command and control agencies by working cooperatively with private sector firms, by, for example, providing high quality and valued environmental services? Third, are attempts made by governments to integrate environmental considerations into the institutions of industrial policy? Fourth, do industrial environmental improvement policies take advantage of the opportunities for industrial environmental improvement afforded by openness to trade and investment? Fifth, do governments in these economies price natural resources and raw materials close to their international scarcity values?

To anticipate the results of our analysis, we find that even within low income countries, there is evidence that industrial capabilities building contributes to country-level industrial competitiveness (as measured by the

UNIDO CIP index), and that policy integration practices contribute positively to environmental improvement (as measured by the intensity of carbon dioxide emissions). In both domains, however, these results are weak and the scope of the contribution is very modest. In most of the low income countries that are considered in our survey analysis, weakness in the basic enabling conditions stymies the incipient efforts of low income countries to engage in industrial capability building. In addition, however, there is considerable evidence that some of the basic experience of the East Asian NIEs with respect to industrial capability building and policy integration has not been taken up by many low income countries and most likely by some of the multilateral agencies working to promote the development of these low income economies. We find, for example, that policies and strategies that support openness to trade and investment have not been matched by requisite demand-inducing policies and strategies to promote industrial capability building. More generally, initiatives to promote the environmental improvement of industry through policy integration are in their early formative stages at best in most of the low income countries under study.

10.2 Assembling Data on Industrial Support Institutions in Low Income Economies

Since there is little published data on institutional effectiveness in low income economies, our first task was to develop a low-cost approach to gathering information on the presence and effectiveness of technology and environmental strategies, institutions, and policies in a sample of the low income economies. Assessing strategy and institutional and policy effectiveness is a tremendously difficult challenge. There are at least three ways in which this might be done. One might go about this task by undertaking in-depth and extensive case studies of individual countries. Another widely used approach involves a modified Delphi method to draw out convergent views of key stakeholders with respect to strategy and the effectiveness of policies and institutions that support a particular upgrading strategy. Neither of these research protocols, however, met our need for a parsimonious and low-cost tool that could be applied to a significant number of low income countries. For this reason the approach adopted here uses a modified version of a technology-needs-assessment protocol developed by Hobday (2002). The technology needs assessment (TNA), as developed by Hobday, requires key stakeholders in a country to complete a relatively short questionnaire on institutional capabilities in that country. Aggregation of survey responses generates both an overall score on the needs-assessment protocol as well as an identification of areas of strength and weakness. This TNA was adapted to cover the range of strategies, institutions, and policies pertinent to industrial capability building and policy integration.

In order to ensure the modified TNA instrument met our needs, a draft survey instrument was pre-tested in four low income countries. Based on the feedback received from this pre-test phase, a revised survey instrument was prepared. As shown in Appendix 10A, the final survey instrument asked questions about (*a*) vision and strategy; (*b*) institutions and policies; and (*c*) institutional capability.

Our protocol for collecting data was as follows. An initial review of published data availability, particularly on the dependent and independent variables used in Chapters 2 and 3 to test hypotheses about the impact of policy integration on industrial competitiveness and on the CO_2 intensity of industrial value added, led us to narrow our focus to a sample of 27 low income countries in Asia, Africa, Latin America and the Caribbean, and in the former Soviet Union for which published data were available. The countries participating in the survey are listed in Table 10.1 and they include six countries from Asia, two from Latin America and the Caribbean, 14 from sub-Saharan Africa, one from the Middle East and North Africa, and three from the former Soviet Union/former Soviet bloc. In each of the countries, approximately 10 key respondents were selected for participation in the survey. Respondents were selected on the basis of their direct knowledge of the presence and effectiveness of technology upgrading and environmental initiatives within the country. Respondents were selected from four different groupings: government agencies, industry associations, multilateral development agencies, and research institutes. In each case, the respondent was contacted by the local United Nations Industrial Development Organization (UNIDO) office and the survey was completed during an in-person interview. Data were obtained from a total of 27 low income countries and from an aggregate total of 273 respondents.

In the empirical analysis of survey results that follows, it is important to emphasize that the variables used from the survey refer to the *mean* response of all respondents to particular questions in particular countries. It is also important to note that each respondent's answer measures their *perception* of the effectiveness of strategies, institutions, and policies linked to technological and

Table 10.1. Low-income countries in the survey data set

Bangladesh	Bolivia	Cambodia	Cameroon
Côte d'Ivoire	Ethiopia	Ghana	Indonesia
Kenya	Kyrgyz Republic	Mali	Mongolia
Nepal	Nicaragua	Nigeria	Rwanda
Senegal	Sri Lanka	Sudan	Uganda
Uzbekistan	Vietnam	Yemen	Zambia
Zimbabwe	Honduras		

environmental upgrading. That is to say, respondents are asked to rank the effectiveness of particular strategies, policies, and institutions on a Likert scale.

10.3 Analysis of the Survey Data on Institutional Effectiveness

Our first step is to examine whether the country-level indicators of perceived institutional effectiveness obtained through the survey data are correlated with industrial performance in the low income countries. As in Chapter 2, we use the technique of multiple regression analysis to assess the degree to which our survey variables affect countries' industrial performance. As in Chapter 2, our dependent variable is UNIDO's Competitive Industrial Performance index (*CIP*). Independent variables in our regressions on CIP include data collected from published sources and used in the regressions in Chapter 2, particularly trade as a share of GDP or *TRDY,* a composite variable on physical infrastructure and human capital (*TELHMINDEX*) collected from the World Bank's *World Development Indicators, 2004* (World Bank 2004), and a measure of macroeconomic stability, the Dollar Index collected from Dollar (1992), plus several variables collected from our survey data (see discussion below). This enabled us to re-estimate the regression equations estimated in Chapter 2 for our sample of low income countries, but with more finely grained measures of institutions. Thus, in each regression, our survey-based measures of institutional effectiveness replace those based on published data in Chapter 2. The purposes of this analysis are to validate, to some degree, the survey data obtained, and to test our policy integration hypotheses in a sample of the low income countries.

The regressions estimated based on published data in Table 2.1 in Chapter 2 took the following general form:

$$CIP = \mathrm{a}_1 + \mathrm{a}_2\, TRDY + \mathrm{a}_3\, DOLLAR + \mathrm{a}_4\, TELHMINDEX + \mathrm{a}_5\, INSTITUTIONS$$

where *CIP* is UNIDO's Competitive Industrial Performance index, *TRDY* is the share of trade in GDP, *DOLLAR* is the Dollar Index, a measure of macroeconomic stability, *TELHMINDEX* is a composite index of physical infrastructure and human capital, and *INSTITUTIONS* is a composite index of institutional effectiveness. Before proceeding to our empirical results more needs to be said about our institutions variables.

Using the results of the country surveys, we constructed four different measures of the perceived effectiveness of institutions. The first is *WEBBUR*, a measure of the effectiveness of governments' institutions of industrial policy in our sample of low income countries. Following Evans and Rauch (1999), who pioneered the development of robust empirical measures of the effectiveness of government bureaucracies, *WEBBUR* is the sum of scores on

seven different questions designed to capture respondents' judgments of the effectiveness of the institutions of industrial policy.[2]

We also constructed variables to measure governments' strategies, policies, and institutions aligned with more specific pathways to technology upgrading. One of the advantages of the survey data is that it allows us to consider different policy approaches, rather than just an aggregate assessment of industrial capabilities. This is especially important in that, given the resource and other constraints of low income economies, policy approaches tend to be unevenly developed. Policies and approaches that are less demanding on government science and technology capabilities, such as policies to promote learning within global value chains, are likely to be more developed than those that depend on the construction of a broad-based, government-focused, national innovation system.

Following the three pathways to industrial capability building identified in Chapter 2, we construct measures of perceived institutional effectiveness linked to (1) developing a national innovations system (*NINNSYS*), (2) promoting the development of large local firms linked to the global economy (*LARGEFIRMS*), and (3) by linking local small and medium sized firms to the global value chains of OECD multinationals (*SMEMNC*). The national innovations systems pathway to technological upgrading variable, *NINNSYS*, was measured by summing responses to three questions designed to assess governments' strategy, policies, and institutions as they affect the development of a national innovation system.[3] The promotion of large firms linked to the global economy pathway to technological upgrading variable, *LARGEFIRMS*, is measured by summing responses to five survey questions which assess the degree to which our respondents perceived that governments' industrial strategy, policies, and institutions supported the development of large local firms.[4] The technological

[2] The questions focused on the percentage of higher-ranking officials in industrial support institutions that entered government employment through a formal examination system; the average number of years spent by a typical higher-level official in one of these institutions during his career; the prospects for promotion of someone who enters one of these institutions through a competitive examination; the approximate number of levels an official can expect to move up over their career; the frequency with which high-level officials in these agencies spend a substantial part of their careers in the private sector, alternating private and public sector activity; the size of the gap between salaries and perquisites, not including bribes or other extra-legal income, of higher officials in these industry support institutions relative to those of private sector managers with comparable training and responsibilities; the importance of civil service exams for entry into these agencies; and how favorably, among graduates of the country's most elite universities, a public sector career in one of these institutions is considered.

[3] The questions are: to what degree is the government's industrial strategy aimed at building the overall science and technology infrastructure of the country? How effective are government science and technology agencies and government standards agencies? How effective are government national science and technology agencies in working with economic agencies to insure that technology upgrading is part of industrial policies?

[4] The questions are: to what degree does the government target for support a small number of leading firms? To what degree does the government promote joint public–private industry

upgrading pathway variable represented by linking small and medium sized firms to the global value chains of OECD multinationals, *SMEMNC*, is measured by summing the responses to five questions designed to assess respondents' sense of the adequacy of government strategy, policies, and institutions designed to increase the participation of small and medium sized firms in the global value chains of OECD multinationals.[5]

We then linked respondents' answers to questions about the capability of government bureaucracies to promote industrial development (*WEBBUR*) to each of the upgrading strategies (*NINNSYS*, *LARGEFIRMS*, and *SMEMNC*) by multiplying our bureaucratic capability variable by each of the pathways to upgrading variables. The three resulting variables, *WEBBUR*NINNSYS*, *WEBBUR*LARGEFIRMS*, and *WEBBUR*SMEMNC*, essentially measure the effectiveness of government industry-oriented bureaucracies in pursuing technological upgrading through one of the pathways to upgrading identified in Chapter 2. These composite variables provide a more finely grained assessment of the capability of government agencies (or *INSTITUTIONS*) to pursue each upgrading strategy. Because of this, we estimate three separate regression equations of the form (one for each of the heuristic pathways to industrial capability building):

$$CIP = \mathrm{a}_1 + \mathrm{a}_2\, TRDY + \mathrm{a}_3\, DOLLAR + \mathrm{a}_4\, TELHMINDEX + \mathrm{a}_5\, INSTITUTIONS$$

In each equation, *INSTITUTIONS* is measured by one of our composite institutional variables. Because of possible endogeneity between several of our right-hand-side independent variables, as in Chapter 2, estimation is by two-stage least squares. Following the estimation procedure of Chapter 2, we instrument openness to trade (*TRDY*) with a constructed trade share (*LFR*) taken from Frankel and Romer (1999) and we instrument institutions, following Hall and Jones (1998) and Dollar and Kraay (2002), with the fraction of a country's population that speaks English (*ENGFRAC*) and the fraction of a country's population that speaks a major European language (*EURFRAC*).

councils in priority industries? To what degree do government policies promote joint ventures between large local firms and foreign firms? How effective is the government agency charged with promoting private investment in industry? To what degree do government technology support policies help large local firms acquire sufficient technological capabilities to compete in the international economy?

[5] The questions are: to what degree does the government actively promote small and medium sized local firms as suppliers to major multinational firms? How effective is the government agency dedicated to supporting small and medium sized firms with management and technical advice? How effective is the public or private agency providing low interest loans or financing to small and medium sized firms? How effective are government policies to support technological upgrading by small and medium sized enterprises? To what degree does the government's small and medium enterprise technology support agency link local SMEs, through local industry upgrading programs, to the global value chains of MNCs?

Estimation is in log-log form. The two-stage least squares estimates for these equations are presented in Table 10.2. Three results deserve mention. First, in two of three of the two-stage least squares (TSLS) regression equations (equations 2 and 3), institutions (*WEBBUR*LARGEFIRMS* and *WEBBUR*SMEMNC*) trump openness and macroeconomic stability. This is powerful testimony to the impact of institutions on competitive industrial performance in our sample of low income economies. Second, at least in this sample of low income economies, there is some evidence that governments are successfully promoting competitiveness by promoting large firms linked to the global economy (the regression coefficient on the variable *WEBBUR*-LARGEFIRMS* is of the expected sign, positive, and it is statistically significant) and by linking small and medium sized firms to the global value chains of multinationals (the regression coefficient on the variable *WEBBUR*SMEMNC* also has the expected sign, positive, and it too is statistically significant). In both of these equations, our composite infrastructure variable (*TELHMINDEX*) is also statistically at the 0.05 level with the expected sign. Given the difficulty of building a national innovation system and using it to promote industrial competitiveness, we are not surprised that *WEBBUR*NINNSYS* was not statistically significant. Finally, as we also expected, given the weaknesses in institutional capabilities in the poorest of the rest, none of these equations performs particularly well—for example,

TABLE 10.2. Two-stage least squares regression equations on Log (*CIP*)

Independent variable	Equation 1	Equation 2	Equation 3
C	−15.1	−12.52	−14.59
Log (*TRDY*)	0.01	−0.14	0.404
	(0.02)	(−0.19)	(0.59)
Log (*DOLLAR*)	0.47	−0.19	0.008
	(1.74)	(−0.90)	(0.03)
Log (*TELHMINDEX*)	0.47	0.39	0.28
	(1.78)	(2.49)**	(2.18)**
Log (*WEBBUR*NINNSYS*)	2.33		
	(1.55)		
Log (*WEBBUR*LARGEFIRMS*)		1.79	
		(3.46)***	
Log (*WEBBUR*SMEMNC*)			1.63
			(4.28)***
$\bar{R}^2$	−0.74	.38	−0.03
Equation *F* statistic	0.72	2.06	1.48
N	10	19	15

Notes: As is well known, adjusted R^2 may be negative with TSLS. *** indicates statistical significance at the 0.01 level. ** indicates statistical significance at the 0.05 level.

none of the equations is statistically significant. But when we 'tested down',[6] as suggested by Hendry (1985), Hendry and Richards (1982, 1983) and Gilbert (1986, 1989), we find that both our institutions variables (*WEBBUR*SMEMNC* and *WEBBUR*LARGEFIRMS*) and our composite infrastructure variable (*TELHMINDEX*) are statistically significant as are both equations in these 'simpler' regressions.[7] This provides substantial additional support for our central hypothesis that effective institutions of industrial policy, particularly those that emphasize technological upgrading through either a large firm strategy linked to the global economy or a strategy that links small and medium sized firms to the global value chains of OECD multinationals, are important drivers of the competitiveness of industrial firms in this sample of low income economies.

Our next step was to re-estimate the environmental policy integration regression equations in Chapter 3 by replacing the published measures of institutions in those equations with our survey measures of environmental institutions and the linkage of those institutions to industry and to the institutions of industrial policy. As in Chapter 3, we estimated two-stage least squares regression equations of the form:

$$CO_2IND = \mathrm{b}_0 + \mathrm{b}_1\, TRDY + \mathrm{b}_2\, FDIY + \mathrm{b}_3\, DP + \mathrm{b}_4\, INSTITUTIONS$$

where CO_2IND is the carbon dioxide intensity of industrial value added, as in Chapter 3, *TRDY* is the share of trade in GDP, *FDIY* is the share of foreign direct investment in GDP, *DP* is the real price of a liter of diesel fuel, a crude measure of the cost of energy, and *INSTITUTIONS* is one of two measures of

[6] Testing down requires using a redundant variables test or a Wald *t* or *F* test to remove redundant variables from regression equations. We used a redundant variables *t* test. The *F* test statistic for the Log (*TRDY*) and Log (*DOLLAR*) is 0.27 for equation 3 in Table 10.2 indicating that we cannot reject the hypothesis that the regression coefficients on these variables in that table are different from zero. The *F* statistic for Log (*TRDY*) and Log (*DOLLAR*) is 0.42 for equation 2 in Table 10.2 indicating that we cannot reject the hypothesis that the regression coefficients on these variables in that table are not different from zero.

[7] The simpler equation for *WEBBUR*SMEMNC* is Log (*CPI*) = −13.49 + 0.30*Log (*TELHMINDEX*) + 1.70*Log (*WEBBUR*SMEMNC*). The *t* value for the coefficient on *TELHMINDEX* is 2.12 and it is significant at the 0.05 level. The *t* value for the regression coefficient on *WEBBUR*SMEMNC* is 4.01 and it is significant at the 0.01 level. Adjusted R^2 is 0.11 and the equation *F* statistic is 3.27 and it is statistically significant at the 0.10 level. The tested down equation for *WEBBUR*LARGEFIRMS* is Log (*CPI*) = −13.75 + 0.38*Log (*TELHMINDEX*) + 1.75*Log (*WEBBUR*LARGEFIRMS*). The *t* value for the coefficient on *TELHMINDEX* is 3.23 and it is significant at the 0.01 level. The *t* value for the regression coefficient on *WEBBUR*LARGEFIRMS* is 4.58 and is significant at the 0.01 level. Adjusted R^2 is 0.47 and the equation *F* statistic is 4.86 and it is statistically significant at the 0.05 level. The simpler equation for *WEBBUR*NINNSYS* is Log (*CPI*) = −12.12 + 0.47*Log (*TELHMINDEX*) + 1.46*Log (*WEBBUR*LARGEFIRMS*). The *t* value for the coefficient on *TELHMINDEX* is 2.14 and it is significant at the 0.10 level. The *t* value for the regression coefficient on *WEBBUR*-NINNSYS* is 1.16 and it is not statistically significant. Adjusted R^2 is −0.02 and the equation *F* statistic is 1.94 and it is not statistically significant.

environmental institutions. As in Chapter 3, all variables except our institution variables are from World Bank (2004). We used our survey data on a sample of the poorest of the rest to construct two measures of the effectiveness of environmental institutions. The first is *WEBBUR*ENVREG*, a measure of the stringency of the environmental regulatory system. *ENVREG* is a composite measure of the stringency of environmental regulations taken from our survey of a sample of the poorest of the rest[8] and *WEBBUR* is our measure of bureaucratic capability. The second is *WEBBUR*ENVSER*, a measure of the degree to which environmental support institutions provide high quality services to the private sector. *ENVSER* is a composite variable that sums respondents' answers to three survey questions that provide an assessment of the quality of environmental services provided to the private sector[9] and *WEBBUR* is our measure of bureaucratic capability.

Because of the possibility of endogeneity between several of our right-hand-side independent variables, estimation of our CO_2IND equations is by two-stage least squares where we instrument *TRDY*, as above, with a constructed trade share (*LFR*) and institutions, as above, by the share of the population in a country that speaks English (*ENGFRAC*) and the share of the population in a country that speaks a major European language (*EURFRAC*). Because of the wide range of variability in our dependent variable (CO_2IND) and a small sample size, both equations were estimated in log-log form.[10] Results appear in Table 10.3. Three findings deserve mention. To begin with, the regression coefficient on our environmental regulatory variable (*WEBBUR*ENVREG*) has the expected negative sign, but it is statistically insignificant. This, no doubt, reflects the relatively weak nature of environmental regulatory agencies in this sample of the poorest of the rest. Second, our environmental service variable (*WEBBUR*ENVSER*) is statistically significant at the 0.01 level with the expected negative sign. This suggests that in this sample of the poorest of the rest, environmental services provided by environmental support institutions—that are competent and able to charge for their services, that routinely evaluate the quality of the services they provide, and that have good relations with private sector industry—work to lower the CO_2 intensity of industrial value added. This

[8] *ENVREG* is the sum of respondents' answers to two survey questions: does your country have a tough, competent but fair environmental regulatory agency that monitors and enforces the country's emissions standards? Do environmental regulators work closely with private sector firms and industry associations to find solutions to pollution that do not undermine the viability of private sector manufacturing firms?

[9] *ENVSER* sums the answers to the following three questions: do government agencies in your country charge firms for participation in government run environmental improvement programs? Does government routinely evaluate the effectiveness of technological environmental support institutions for industry by surveying private sector clients? Do industrialists see government environmental technology representatives as highly skilled and knowledgeable?

[10] The mean value of CO_2IND is 36.5 lb of CO_2 per dollar of industrial value added with a range from 666.6 to 1.1 and a standard deviation of 131.8.

TABLE 10.3. Two-stage least squares regression equations on Log (CO_2IND)

Independent Variables	Equation 1	Equation 2
C	−4.96	−2.94
Log (*TRDY*)	−0.41	1.52
	(−0.40)	(1.53)
Log (*FDIY*)	0.006	−0.31
	(0.03)	(−1.38)
Log (*DP*)	−0.48	0.26
	(−0.69)	(0.32)
Log (*WEBBUR*ENVREG*)	−1.62	
	(−0.81)	
Log (*WEBBUR*ENVSER*)		−3.43
		(−2.98)***
$\bar{R}^2$	−0.69	−0.54
Equation *F* statistic	0.56	0.96
N	17	17

Notes: As is well known, adjusted R^2 can be negative in TSLS regressions. *** indicates statistical significance at the 0.01 level.

is testimony to the importance of embedded autonomy of capable environmental support institutions providing highly valued services. Finally, it needs to be noted, neither of these equations performs very well—neither equation is statistically significant. Given the weaknesses in institutions in these economies, this finding is not particularly surprising. But when we 'tested these equations down' by use of a redundant variables *F* test, the simpler version of equation 2 in Table 10.3 performed quite well demonstrating the importance of linking the provision of environmental services to the private sector to capable agencies who can charge for their services because the private sector values them.[11]

[11] The redundant variables *F* test on the variables *TRDY*, *FDIY*, and *DP* in equation 2 in Table 10.3 revealed that we could not reject the hypothesis that the regression coefficients on these variables are not significantly different from zero (the *F* statistic = 0.57). The simpler TSLS regression equation is Log (CO_2IND) = −0.406 − 1.95*Log (*WEBBUR*ENVSER*). The *t* value for the regression coefficient on *WEBBUR*ENVSER* is −3.58 and it is significant at the 0.01 level. Adjusted R^2 for the equation is 0.13 and the equation *F* statistic is 3.76 and it is significant at the 0.10 level. On the other hand, equation 1 in Table 10.3 continued to perform poorly as the variable *WEBBUR*ENV* failed to be statistically significant even though it had the expected sign (negative). This offers more evidence of the relative ineffectiveness of environmental regulatory agencies in this sample of the poorest of the rest.

10.4 Enabling Conditions for Industrial Capability Building and Policy Integration

The results of these statistical analyses provide some preliminary and partial support for the claim that industrial capability building is a driver of industrial competitiveness in low income countries, and that policy integration can contribute to improving the environmental performance of industry in these same low income countries. Where industrial support institutions are judged to be effective, low income countries tend to have stronger competitiveness outcomes as measured by the UNIDO CIP index. But the survey results also show that the relationships are weak and are modest in their impact. Why is this the case? Our review of allied data for the sample low income countries suggests that a major factor is the weakness in basic enabling conditions in low income countries.

While political stability, openness to trade and investment, macroeconomic stability, investment in physical and human infrastructure, and bureaucratic capability are among the enabling hallmarks of the East Asian NIEs (World Bank 1993; Rock 2002*a*), these conditions do not characterize most low income economies where polities are unstable,[12] openness is low,[13] macro-economies are unstable,[14] physical and human infrastructures are poorly developed,[15] and government bureaucracies[16] and environmental regulatory agencies[17] are weak. It is difficult to envision policy integration working in such environments. What this means is that governments in these economies and donors providing aid to these economies need to work extra hard to provide the basic enabling conditions for more sustainable industrial development.

The returns to such a strategy are quite substantial, even in the poorest of the rest. A one standard deviation 'improvement' in each of these variables—openness (*TRDY*), macroeconomic stability (*DOLLAR*), physical and human infrastructure (*TELHMINDEX*), and bureaucratic capability (*WEBBUR*SMEMNC*)—evaluated at mean values for the low income economies in equation 3 (on industrial competitiveness) of Table 10.2 would improve

[12] The average score on political stability is 0.41 in the East Asian NIEs, 0.15 in the rest, and only −0.51 in the poorest of the rest.

[13] The share of trade in GDP (*TRDY*) averages 150% in the East Asian NIEs, 66% in the rest, and 62% in the poorest of the rest.

[14] The mean value of the Dollar Index is 107 for the East Asian NIEs and 124 for the rest. It is even higher for the poorest of the rest (141).

[15] Our composite infrastructure variable, *TELHMINDEX*, averages 35 in the East Asian NIEs, 30 in the rest, and only 5.2 in the poorest of the rest.

[16] The mean value for the bureaucratic capability of government (*WB*) is 11 for the East Asian NIEs, 6 for the rest, and 2 for the poorest of the rest.

[17] The mean value for the stringency of environmental regulations is 0.77 for the East Asian NIEs, 0.13 in the rest, and 0 for the poorest of the rest.

industrial competitiveness by 48% (increasing from 0.138 to 0.205) in the low income economies. Since 21 of the 26 countries in our sample of low income economies have competitiveness values less than 0.205, and 16 of 26 have competitiveness values that are more than one standard deviation below 0.205, the gains from improving these basic conditions appear to be quite large. A similar gain can be had for those low income economies following an upgrading strategy based on a large firm strategy.[18] Looked at another way, if we assume that low income economies performing more poorly on any of these policy variables than the low income economy in our sample with the 'best' industrial competitiveness index[19] are unlikely to be able to successfully practice policy integration, then 24 out of 26 of the low income economies in our sample fail to meet these minimal conditions. This suggests that there is ample opportunity in the poorest of the rest to reap these gains. If we relax this assumption and assume, instead, that low income economies with values of one standard 'deterioration' compared to the mean values on at least one of these policy variables are unlikely to be able to successfully practice policy integration, more than one-third (35%) of the low income economies in our sample appear to have little chance of success. These countries may well provide the best opportunity for establishing the minimal basic enabling conditions for more sustainable industrial development. But this line of reasoning also suggests that the poorest of the rest have to overcome a particularly daunting set of challenges before they can reasonably be expected to practice more successful sustainable industrial development.

10.5 Next Steps to Industrial Capability Building and Policy Integration

Beyond strengthening the enabling conditions for industrial capability building and policy integration, what other steps might low income countries take to strengthen institutional support for industry-led development? To answer this question, we consider in more depth the case of one of our sample low income countries, Ghana, and supplement the results of the survey for this country with field interviews. We chose Ghana because it is a prototypical low income economy. Its industrial competitive index (0.14) is virtually equal to the average for our sample of the low income countries (0.137). Although it is a bit more open ($TRDY = 93\%$) than the sample as a whole (58%), it has suffered from more macroeconomic instability ($DOLLAR = 248$) than the

[18] At mean values for the variables in equation 2 in Table 10.2, a one standard deviation improvement in *WEBBUR*LARGEFIRMS* increases competitiveness by 38% (from 0.145 to 0.20).

[19] Indonesia with a *CIP* of 0.29 is more than two standard deviations above the mean value for the industrial competitiveness index for the low income economies.

sample low income countries (*DOLLAR* = 147). The value on our composite infrastructure/human capital variable (*TELHMINDEX*) is low (20) as it is in the sample of low income countries (30). And Ghana's scores on our upgrading institutions variables (*WEBBUR*SMEMNC*, *WEBBUR*LARGEFIRMS*, and *WEBBUR*NINNSYS*) are all within about 7% of the mean for our sample of the poorest of the rest (532 for Ghana versus 495 for the rest for *WEBBUR*SMEMNC*, 462 for Ghana versus 431 for the rest for *WEBBUR*LARGEFIRMS*, and 397 for Ghana versus 389 for the rest for *WEBBUR*NINNSYS*).

Consistent with the pathways to industrial capability building identified in Chapter 2, Ghana has sought to build industrial capability in a series of targeted industrial sectors, both by promoting foreign direct investment in these sectors and by encouraging the participation of small and medium sized enterprises as suppliers in global value chains. In pursuing this goal, Ghana has adopted many of the standard policy tools observed in the East Asian NIEs, including setting up free-trade zones for investors in targeted industries, offering tax incentives to foreign investors, providing 'one-stop-shopping' processing for licensing requests, and training programs for workers in targeted industries. As shown in Table 10.4, Ghana has a wide range of institutions and policies in place. These policies have been given additional weight through the creation of a Ministry for Private Sector Development, and by the launching of several presidential special initiatives focused on coordinating the activities of different ministries in support of targeted industries, such as the garment textile industry. Ghana has ambitious goals for these initiatives, including the creation of 70,000 new jobs in the garment textile industry alone.

What success has been achieved to date? In our questionnaire surveys we asked respondents to assess the effectiveness of strategies, institutions, and policies in support of industrial capability building. We supplemented these survey results in Ghana by conducting interviews with government ministries, firms, and industry associations. As reported in our surveys, and as confirmed in field interviews, Ghana is viewed by our survey respondents as being somewhat effective in attracting foreign investment, in promoting exports, and in identifying priority industries based on market opportunities. Clearly respondents recognize that the government has made it a priority to promote foreign direct investment and to promote export-oriented industries, and most respondents can cite examples of industries where this is occurring to some modest degree. Consistent with the assessment of strategies, the institutions in Ghana responsible for promoting exports and investment are viewed as somewhat effective.

The government, however, is viewed by our survey respondents as somewhat less successful in targeting technological upgrading as the key for industrial development (as compared to a focus on growing exports), and in promoting any of the three pathways to technological upgrading. Most of the technological upgrading policies (e.g. policies to support technological

TABLE 10.4. Selected institutions and policies in Ghana

Support institution	Ghana institution	Ghana policy
Policy making	Ministry of Trade and Industry; Ministry of Private Sector Development	Macroeconomic policy. President's Special Initiatives in garments, cassava, and palm oil. Accelerated and uniform goods clearance. Reduced time for business start-up. Harmonized tariffs. Privatization of state-owned enterprises
Private industry associations	Association of Ghana Industries. Industry associations in several sectors, including food processing	Policy advocacy in areas of cost of credit, business regulation, business law. Business assistance
Export processing zones with tax incentives	Ghana Free Zones Board	Lower income tax rates. Tax holidays. Reduced export duties. Tax holiday (0% income tax for 10 years). 100% foreign ownership allowed
Industrial estates with reliable infrastructure	TEMA export processing zone	One stop regulation. Fast track customs clearance. Basic infrastructure recently completed
SME financing and cluster support	Banking reform	Access to capital major business concern for SMEs
Industry R&D and productivity centers	Ministry of Science and Environment	Mainly public institutions with modest links to private sector, e.g. Oil Palm Research Institute; Crops Research Institute
Government Institute of Standards	Ghana Standards Board	Building basic standards infrastructure. Limited involvement in ISO 9000 or 14000 certification
Export promotion agency	Ghana Export Promotion Council	AGOA initiatives. Some trade visits. Retention of foreign exchange earnings
Investment promotion agency	Ghana Investment Promotion Center	Investor trade fairs. Efforts to cultivate foreign investors in target industries under PSI. Technology transfer
Environmental Protection Agency	Ghana EPA	Environmental impact assessment. Performance rating and disclosure. Recent cleaner production initiatives

upgrading in SMEs, university-industry technology linkage programs, and tax incentives for private industry R&D expenditures) are judged by our survey respondents to be less than somewhat effective.

What these results suggest is that Ghana is somewhat effective in promoting exports, foreign investment, and private sector investment, but that, for the most part, strategies, institutions, and policies that focus on technological upgrading are not very effective. Ghana appears to be focused on one half of the equation of industrial competitiveness (promoting exports, foreign investment, and private investment) but is ignoring the other half of the equation—technological upgrading. Given the importance of technological upgrading to industrial competitiveness, Ghana, by focusing on promoting exports and investment, may well get trapped in the lower end of the manufacturing value chain because it has failed to emphasize in its strategies, institutions, and policies, technological learning and upgrading. As Ghana continues to develop its industrial development strategy, it will be important that more attention be given to technology upgrading and to appropriate pathways to achieving technology upgrading of industry.

The case of Ghana illustrates one of the core claims of our analysis of industrial capability building, namely that simply opening the economy to foreign investment and trade is not sufficient to secure technological and industrial catch up. There are some signs that such industrial capability building can occur in Ghana, especially through participation in the global value chains in the ready-made garment sector and other industries. Success depends upon coordination of policies directed toward industrial capability building along with those directed toward openness. In addition, Ghana will need to continue to strengthen some of the basic enabling conditions for technological upgrading, including macroeconomic stability, reliable infrastructure (water and electricity supply), and transparency in government activities.

How typical is the experience of Ghana of our sample of low income countries as a whole? Because there are substantial differences among the sample low income countries in the effectiveness of policy and institutional variables, at least two different groupings of low income countries are visible. In one group of the sample low income countries—Chile, Colombia, Costa Rica, Peru, South Africa, Turkey, and Venezuela, where industrial competitiveness is in the range of Indonesia (the mean value of *CIP* is 0.24 with a range of 0.18 to 0.31) and where governments have sustained macroeconomic stability (the mean value for *DOLLAR* is 90.7 with a range of 72 to 109), invested substantially in physical and human capital (the mean value of *TELHMINDEX* is 26.5 with a range from 22.2 to 32.1), and created reasonably capable government bureaucracies (the value for *WS* is 6.9 with a range from 5 to 9), attention needs to focus on developing more effective technological upgrading policies and institutions (the mean value of the institutions of industrial policies (*WS*D*) is 0) and on building a credible environmental regulatory agency (the mean value of the stringency of environmental regu-

lations (*ENVSTRING*) is 0) and linking it to the institutions of industrial policy. The experience of the East Asian NIEs in developing effective technology upgrading policies and institutions (Chapter 2) suggests that this will take time and resources. Developing effective technological upgrading policies and institutions requires strengthening the bureaucratic capabilities of industrial policy agencies, embedding them in the private sector, and linking both to a clear upgrading strategy. Because institutional contexts differ quite substantially across countries (Chapter 2), industrial policy entrepreneurs need to craft responses that mesh well with the local institutional context. This requires them to be both strategic and opportunistic.

In another group of our sample low income countries—Bolivia, Cameroon, Ecuador, Egypt, El Salvador, Honduras, Kenya, Madagascar, Malawi, Morocco, Mozambique, Nigeria, Paraguay, Senegal, Tanzania, Uganda, Yemen, Zambia, and Zimbabwe—macroeconomic stability is poor (the mean value of *DOLLAR* is 162 with a range of 113 to 277), the physical and human infrastructure base is weak (the mean value of *TELHMINDEX* is 7.1 with a range of 0.88 to 17.9) and bureaucratic capabilities are limited (the mean value of *WS* is 4.5 with a range of 1.0 to 7.8). Countries in this group face the most formidable challenges. These economies are largely agrarian, they have relatively small industrial bases, and they have even smaller export-oriented industrial bases. Their current comparative advantage in industry is in low-skill, low-wage, labor-intensive dirty industries such as textile dyeing, leather-making, and low-skills electro-plating. These are relatively footloose industries and the very industries that others in East Asia, particularly Korea, Taiwan Province of China, Singapore, and Hong Kong are losing comparative advantage in. Because of this loss of comparative advantage, many of the ‘plants’ in this industry are relocating to this group of countries.

In all of the low income countries, commitments to improving the environmental performance of industry are at a nascent stage. Improving the environmental performance of industry requires substantial investment of time, energy, and resources in building the capacity and capabilities of environmental protection agencies to implement and manage traditional command and control policies. Only after this was done, did regulatory agencies in most of the East Asian NIEs introduce pollution prevention and superior performance policies. This raises an interesting question. Should the nascent environmental protection agencies in this group of low income economies follow this path or should they try to simultaneously develop command and control, pollution prevention, and superior performance policies? Or should they attempt even more innovative alternatives such as integrated pollution control (Hersch 1996)? Because pollution prevention policies and superior performance policies are complements to and not substitutes for sound command and control policies, we suspect that environmental protection agencies in this group of countries would be best served by developing the capacity to manage rigorous command and control programs.

What might these agencies do while command and control capacities are being built? Environmental protection agencies need to be both opportunistic and strategic. That is, they need to look for opportunities where they can intervene to make a difference and where they can learn by doing. This suggests taking a problem-specific approach to capacity and capabilities building. This can mean taking action that either builds on or galvanizes public opinion and/or community pressure. There are several examples in East Asia of how this has already been done. The Department of the Environment in Malaysia (Chapter 3) took advantage of growing community and public dissatisfaction over unabated pollution from crude palm oil mills to fashion a highly effective intervention strategy that successfully de-linked palm oil production and exports from water pollution. This included development of a highly productive relationship with a quasi-public quasi-private science and technology research institute. A local environmental agency in Indonesia (Chapter 4) did much the same when it used a highly publicized pollution case to mount a small-scale monitoring and inspection program that worked. Indonesia's national environmental impact agency, BAPEDAL, has gone one step further by developing a simple environmental business rating program, PROPER (Afsah and Vincent 2000) that relies on public disclosure and shame to get plants to clean up pollution. China's State Environmental Protection Agency has developed a similar public disclosure program for cities (see Chapter 3). Beyond building capabilities in a traditional command and control agency and adopting an opportunistic response to pressing industrial pollution problems, governments in this group of economies might also consider how they might link strengthened regulatory agencies to more effective industrial policy agencies.

Low income countries also have much to gain from a global investment code of environmental conduct binding foreign investors to a commonly agreed upon set of environmental practices. This could be particularly helpful if foreign investors from the OECD abided by a set of environmental requirements similar to those of investors' home countries or economies. Export-oriented industrial plants in these countries might also gain from greening the supply chain programs (see Chapter 7) and other external environmental market pressures (such as 14000 certification and green labeling programs), particularly if they are managed either by foreign investors or donors. They might also stand to gain from a more rapid development of multinational firm-based standards (see Chapter 8).

10.6 Summing Up

Our assessment suggests two main conclusions. First, it is important to pay attention to the different starting conditions attendant upon the three pathways laid out in Chapter 2. The conditions required to build national systems

of innovation are especially demanding. Efforts to link large domestic firms to foreign firms through joint ventures and licensing agreements are sometimes prone to corruption and rent seeking and depend heavily on maintained embedded autonomy. While governments and private sectors in this group of economies will want to examine all three pathways to technology capability building, we suspect that SME participation in global value chains is likely to offer the best opportunity for technological and environmental capability building in this group of economies. Second, the weak starting conditions in this group of economies mean that it is important for governments and firms to leverage external markets and leverage the know-how and capability that can be obtained through engagement in the international economy.

Governments in the rest must also take account of what has changed in the most recent period, compared to the early period (1965–90) when the East Asian NIEs began their technological upgrading and industrial environmental improvement programs. Two key changes in the external environment are highlighted in which the rest must pursue technological and environmental capability building strategies. These aspects of change are the intense competition that currently exists among the rest around participation in the international economy, and the constraints placed on all developing countries by the terms of the WTO.

The efforts of the East Asian NIEs to engage in technology upgrading coincided in the last four decades of the twentieth century with major internationalization and globalization of the world economy. The East Asian NIEs were able to mobilize first-mover advantages in capturing a competitive position within this new international economy through an export-led production strategy. As other low income economies consider engaging in a similar pathway of technological and environmental capability building, they are currently facing intense competition from other developing countries, especially in terms of the opportunities to 'climb the ladder' to higher value-added economic activity. The major implication of this intense competition is that the rest, but particularly the low-income countries, will need to adopt strategies that are even more market driven and demand focused. Simply targeting sectors that have served as the basis for early industrializing elsewhere—for example, apparel and electronics assembly—offers no guarantee of market success (see also Ernst and Ravenhill 1999). Many of the more promising market opportunities may lie in regional market areas and, while agro-based industries may offer promising opportunities, supply-driven approaches are likely to have a high failure rate.

The terms of the WTO act as an additional constraint on the rest pursuing technological and environmental capacity building. Of particular importance are restrictions on policies that favor domestic firms, such as tax incentives that are available only to domestic firms. Prior to the creation of the WTO, promotional privileges offered by investment promotion agencies were frequently conditioned on local content and/or export requirements and specific

technology transfer requirements. There is some evidence that these kind of requirements facilitated high-speed technological activity, but unfortunately, these kinds of conditionality are no longer permitted by the WTO (UNDP 2003).

Throughout East Asia industrialization and technology upgrading remain the core of governments' economic development strategies. Because of the developmental successes of the East Asian NIEs, governments and firms in the rest are attempting to emulate their development strategies. There can be little doubt that this pattern of rapid urban-industrial growth brings with it difficult environmental problems. But the scale of new investment and the availability of cleaner technologies in the OECD suggest the possibility of alternative development trajectories that are less energy, materials, and pollution intensive. The policy challenge is to harness the emerging drivers of cleaner industrial development in ways that offset increases in the scale of output by parallel decreases in the energy, materials, and pollution intensity of economic activity. Tight coordination of environmental, industrial, and technology policies within a framework of policy integration in the low income economies will be needed to achieve this goal.

Appendix 10A. Low Income Economies Survey Instrument

1. In your assessment, is there a clear and agreed upon vision among key government officials and private sector actors regarding industrial development in this country?
   Not at all ___________________
   Somewhat ___________________
   Very much so ________________
   Do not know ______________

2. Which of the following strategies are currently used in this country to promote industrial development?

	Not part of policy	Part of policy but *not* successful	Part of policy and partially successful	Part of policy and very successful	Do not know
The government actively promotes small and medium sized local firms as suppliers to major multinational firms					
The government targets for support a small number of leading firms within an industrial sector					
The government targets the building of the national technological infrastructure by investing in government science and technology agencies and government standards agencies?					
Government policy is to seek joint ventures between large local firms and foreign firms					

3. Please comment on the following types of industry support policies and institutions in this country.

	Does not exist	Not effective	Somewhat effective	Very effective	Do not know
Government agency charged with promoting private investment in industry					
Government science and technology agencies as part of a public sector national innovation system					

Government national science and technology agencies working with economic agencies to insure that technology upgrading is part of industrial policies					
Government agency dedicated to supporting small and medium sized firms with management and technical advice					
Public or private agency providing low interest loans or financing to small and medium sized firms.					
Joint public–private industry councils in priority industries working to promote competitiveness and industry growth					
Policies to support technological upgrading by small and medium sized enterprises					
Government technology support policies help large local firms to acquire sufficient technological capabilities to compete in the international economy					

4. To what extent do the following statements accurately describe the capability of industry support institutions and environmental support institutions in this country?

Key capability	Disagree strongly	Disagree somewhat	Agree somewhat	Agree strongly	Do not know
Our small and medium enterprise technology support agency links local SMEs, through local industry upgrading programs, to the global value chains of MNCs					
Our national science and technology agencies work closely with economic agencies to insure that technology upgrading is part of industrial policies					
We have a tough, competent but fair environmental regulatory agency that monitors and enforces the country's emissions standards.					
Our environmental regulators work closely with private sector firms and industry associations to find solutions to pollution that do not undermine the viability of private sector manufacturing firms					

Our government routinely evaluates the effectiveness of technological environmental support institutions for industry by surveying private sector clients

Industrialists see government environmental technology representatives as highly skilled and knowledgeable

Government environmental support agencies are able to charge firms for participation in environmental improvement programs

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5. The following questions relate to the bureaucratic capability of government agencies charged with promoting industrial development.

5.1 Approximately what percent of the higher-ranking officials in industrial support institutions enter government employment via a formal examination system?

a. _____ Less than 30%

b. _____ 30%–60%

c. _____ 60%–90%

d. _____ More than 90%

5.2 What is the roughly modal number of years spent by a typical higher level official in one of these institutions during his career?

e. _____ 1–5 years

f. _____ 2–10 years

g. _____ 10–20 years

h. _____ entire career

5.3 What prospects for promotion can someone who enters one of these institutions through an examination early in his career reasonably expect? Assuming that there are at least six steps or levels between an entry-level position and the head of the agency, how would you characterize the possibilities for moving up in the agency? (N.B. more than one answer may apply.)

i. _____ In most cases will move up one or two levels

j. _____ In most cases will move up three or four levels

k. _____ Will move up several levels to the level just below top political appointees

l. _____ In at least a few cases, will move up to the very top

5.4 How common is it for high-level officials in these agencies to spend a substantial part of their careers in the private sector, interspersing private and public sector activity?

m. _____ Almost never

n. _____ Unusual

o. _____ Frequent but not modal

p. _____ Normal

5.5 How would you estimate the salaries and perquisites, not including bribes or other extra legal income, of higher officials in these industry support institutions relative to those of private sector managers with comparable training and responsibilities?

q. _____ Less than 50%

r. _____ 50%–80%

s. _____ 80%–90%

t. _____ Comparable

u. _____ Higher

5.6 How important are civil service exams for entry into these agencies?

v. _____ No civil service exams, or exams are of trivial importance

w. _____ Ambiguous

x. _____ Civil service exams are an important component of entry into the bureaucracy

5.7 Among graduates of the country's most elite universities, how favorably is a public sector career in one of these institutions considered?

y. _____ A second best option

z. _____ It depends on circumstances

aa. _____ The best possible option

References

Acemoglu, D., Johnson, S., and Robinson, J. A. (2001). 'The Colonial Origins of Comparative Development: An Empirical Investigation'. *American Economic Review*, 91/5: 1369–401.

Aden, J., and Rock, M. T. (1999). 'Initiating Environmental Behavior in Manufacturing Plants in Indonesia'. *Journal of Environment and Development*, 8/4: 357–75.

—— Ahn, K.-H., and Rock, M. T. (1999). 'What is Driving the Pollution Abatement Expenditure Behavior of Manufacturing Plants in Korea?' *World Development*, 27/7: 1203–14.

Afsah, S., and Vincent, J. (2000). 'Putting Pressure on Polluters: Indonesia's PROPER Programme', in D. Angel and M. T. Rock (eds.), *Asia's Clean Revolution: Industry Growth, and the Environment*. Sheffield, UK: Greenleaf Publishing, 157–72.

Allenby, B. (1999). *Industrial Ecology*. New York: Prentice Hall.

Amsden, A. (1989). *Asia's Next Giant*. New York: Oxford University Press.

—— (2003). *The Rise of 'the Rest': Challenges to the West from Late-Industrializing Economies*. New York: Oxford University Press.

Angel, D., and Rock, M. (eds.) (1997). *Asia's Clean Revolution: Industry, Growth and the Environment*. Sheffield, UK: Greenleaf Publishing.

—— —— (2001). 'Policy Integration: Environment and Development in Asia'. Paper prepared for the *Asian Environmental Outlook* Series of the Asian Development Bank. Manila: Asian Development Bank.

—— —— (2003). 'Engaging Economic Development Agencies in Environmental Protection: The Case for Embedded Autonomy'. *Local Environment*, 8/1: 45–59.

Arnold, E., Bell, M., Bessant, J., and Brimble, P. (2000). 'Enhancing Policy and Institutional Support for Industrial Technology Development in Thailand'. December. Mimeo.

Arora, S., and Cason, T. (1995). 'An Experiment in Voluntary Environmental Regulation: Participation in EPA's 33/50 Program'. *Journal of Environmental Economics and Management*, 28: 217–86.

Asheim, B. T. (2000). 'Industrial Districts: The Contributions of Marshall and Beyond', in G. L. Clark, M. P. Feldman, and M. S. Gertler (eds.), *The Oxford Handbook of Economic Geography*. Oxford: Oxford University Press, 413–31.

Asian Development Bank (1997). *Emerging Asia*. Manila: Asian Development Bank.

—— (2000). *Key Indicators of Developing Asian and Pacific Countries*, xxxi. Manila: Asian Development Bank.

—— (2001). *Asian Environmental Outlook*. Manila: Asian Development Bank.

Ausubel, J., and Sladovich, H. E. (eds.) (1996). *Technology and the Environment*. Washington: National Academy Press.

Ayres, I., and Braithwaite, J. (1992). *Responsive Regulation*. New York: Oxford University Press.

Ayres, R., and Ayres, L. (1996). *Industrial Ecology*. Cheltenham: Edward Elgar.

Battat, J., Frank, I., and Shen, X.(1996). 'Suppliers to MNCs: Linkage Programs to Strengthen Local Companies in Developing Countries'. Foreign Investment Advisory Service Occasional Paper No. 6. Washington.: World Bank.

Baumol, W. J., and Oates, W. E. (1988). *The Theory of Environmental Policy*. New York: Cambridge University Press.

Bell, M., and Pavitt, K. (1992). 'Accumulating Technological Capability in Developing Countries in World Bank'. *Proceedings of the World Bank Annual Conference on Development Economics: 1992*. Washington: World Bank, 275–81.

Bell, R. M., and Albu, M. (1999). 'Knowledge Systems and Technological Dynamism in Industrial Clusters in Developing Countries'. *World Development*, 27: 1715–34.

Bello, W., and Rosenfeld, S. (1992). *Dragons in Distress*. New York: Food First.

Bennett, D. (2002). *Innovative Technology Transfer Framework Linked to Trade for UNIDO Action*. Vienna: United Nations Industrial Development Organization.

Bernard, M., and Ravenhill, J. (1995). 'Beyond Product Cycles and Flying Geese: Regionalization, Hierarchy, and the Industrialization in East Asia'. *World Politics*, 47/2: 171–209.

Berry, A., and Levy, B. (1994). 'Indonesia's Small and Medium-Size Exporters and their Support Systems'. Policy Research Working Paper 1402. Washington: World Bank.

Bhagwati, J. (2004). *In Defence of Globalization*. Oxford: Oxford University Press.

Birdsall, N., and Wheeler, D. (1992). 'Trade Policy and Industrial Pollution in Latin America: Where are the Pollution Havens', in P. Low (ed.), *International Trade and the Environment*. World Bank Discussion Paper No. 159. Washington: World Bank, 159–68.

Booth, A. (1989). 'Indonesian Agriculture in Comparative Perspective'. *World Development*, 17/8: 1235–54.

Bouton, L., and Sumlinski, M. A. (1995). *Trends in Private Investment in Developing Countries: Statistics for 1970–94*. Washington: International Finance Corporation.

—— —— (1999). *Trends in Private Investment in Developing Countries: Statistics for 1970–98*. Washington: International Finance Corporation.

Brandon, C., and Ramankutty, R. (1993). *Toward an Environmental Strategy for Asia*. Washington: World Bank.

Bridge, G. (2002). 'Grounding Globalization: Prospects and Perils of Linking Economic Processes of Globalization to Environmental Outcomes'. *Economic Geography*, 78: 361–86.

Campos, J. E., and Root, H. L. (1996). *The Key to the Asian Miracle*. Washington: Brooking Institution.

Carmichael, G., and Sherwood Rowland, F. (1998). 'Development of Asian Mega Cities: Environmental, Economic, Social and Health Implications'. US Global Change Research Program, Seminar Series, June.

Cembureau (1998). *World Statistical Review No.18, World Cement Market in Figures*. Brussels: Cembureau.

Chang, Ha-Joon (2002). *Kicking Away the Ladder*. London: Anthem Press.

—— and Cheema, A. (2001). 'Conditions for Successful Technology Policy in Developing Countries—Learning Rents, State Structures, and Institutions'. UNU: INTECH Discussion Paper No. 2001–8. Maastricht, The Netherlands: UNU: INTECH.

Chertow, M., and Esty, D. (1997). *Thinking Ecologically: The Next Generation of Environmental Policy*. New Haven: Yale University Press.

Christensen, K., Nielson, B., Doelman, P., and Schellman, R. (1995). 'Cleaner Technologies in Europe'. *Journal of Cleaner Production*, 3/1–2: 67–70.

Christmann, P., and Taylor, G. (2001). 'Globalization and the Environment: Determinants of Firm Self-Regulation in China'. *Journal of International Business Studies*, 32: 439–58.

Churchill, P. R. (1995). 'Local Government Initiative in Southeast Asia: Toward a New Growth Model'. *Journal of Asian Business*, 11/1: 40–76.

Clark, G. L. (1998). 'Stylized Facts and Close Dialogue: Methodology in Economic Geography'. *Annals of the Association of American Geographers*, 88: 73–87.

—— Feldman, M. P., and Gertler, M. (eds.) (2000). *The Oxford Handbook of Economic Geography*. Oxford: Oxford University Press.

—— and Kim, W. B. (eds.) (1995). *Asian NIEs in the Global Economy*. Baltimore: Johns Hopkins University Press.

Cole, M. A., Rayner, A. J., and Bates, M. (1998). 'Trade Liberalization and the Environment: The Case of the Uruguay Round'. *World Economy*, 21/3: 337–47.

Copeland, B. R. and Scott Taylor, M. (2003). *Trade and Environment: Theory and Evidence*. Princeton: Princeton University Press.

Corbett, C. J. (2002). *Diffusion of ISO 9000 and ISO 14000 Certification through Global Supply Chains*. Working Paper. Los Angeles: Anderson School of Management, UCLA.

—— and Kirsch, D. (2000). 'ISO 14000: An Agnostic's Report from the Front Line'. *ISO 9000 and 14000 News*, 2: 4–17.

Cribb, R. (1990). 'The Politics of Pollution Control in Indonesia'. *Asian Survey*, 30: 1123–35.

Dahlman, C. J., Ross-Larson, B. R., and Westphal, L. (1987). 'Managing Technological Development: Lessons from the NICs'. *World Development*, 15/6: 759–75.

Daly, H. (1994). 'Fostering Environmentally Sustainable Development: Four Parting Suggestions for the World Bank'. *Ecological Economics*, 10: 183–7.

Dasgupta, S., Hettige, H., and Wheeler, D. (1997). 'What Improves Environmental Performance? Evidence from Mexican Industry'. *Policy Research Working Paper Series* No. 1877. Washington: World Bank.

Davidson, R., and MacKinnon, J. G. (1993). *Estimation and Inference in Econometrics*. New York: Oxford University Press.

Davies, C. J., and Mazurek, J. (1998). *Pollution Control in the U.S.: Evaluating the System*. Washington: Resources for the Future.

Dean, J. M. (2002). 'Does Trade Liberalization Harm the Environment? A New Test'. *Canadian Journal of Economics*, 35: 819–42.

Deyo, F. C., Doner, R. F., and Hershberg, E. (eds.) (2001). *Economic Governance and the Challenge of Flexibility in East Asia*. Lanham, Md.: Rowman and Little field.

Dicken, P. (2000). 'Places and Flows: Situating International Investment', in G. L. Clark, M. P. Feldman, and M. Gertler (eds.) *The Oxford Handbook of Economic Geography*. Oxford: Oxford University Press, 275–91.

—— (2003). *Global Shift: Transforming the Global Economy*. New York: Guilford Press.

—— Kelly, P. F., Olds, K., and Yeung, H. (2001). 'Chains and Networks, Territories and Scales: Towards a Relational Framework and Analyzing the Global Economy'. *Global Networks*, 1: 89–112.

Ditz, D., and Ranganathan, J. (1997). *Measuring Up: Toward a Common Framework for Tracking Corporate Environmental Performance*. Washington: World Resources Institute.

Dollar, D. (1992). 'Outward-Oriented Developing Economies Really Do Grow More Rapidly: Evidence from 95 LDCs: 1976–85'. *Economic Development and Culture Change*, 40: 523–44.

—— and Kraay, A. (2002). 'Institutions, Trade and Growth'. Carnegie-Rochester Conference Series on Public Policy.

Doner, R. F. (1991). *Driving a Bargain: Automobile Industrialization and Japanese Firms in Southeast Asia*. Berkeley: University of California Press.

—— and Hershberg, E. (1999). 'Flexible Production and Political Decentralization in the Developing World: Elective Affinities in the Pursuit of Competitiveness'. *Studies in Comparative International Development*, 34/1: 45–82.

Dowell, G., Hart, S., and Yeung, B. (1999). 'Do Corporate Global Environmental Standards in Emerging Markets Create or Destroy Market Value?' Working Paper 259. University of Michigan Business School.

Dua, A., and Esty, D.C. (1997). *Sustaining the Asia Pacific Miracle: Environmental Protection and Economic Integration*. Washington: Institute for International Economics.

Eder, N. (1996). *Poisoned Prosperity*. New York: M. E. Sharpe.

Egan, M. L., and Mody, A. (1992). 'Buyer–Seller Links in Export Development'. *World Development*, 20: 321–34.

Erh-Cheng, Hwa (1988). 'The Contribution of Agriculture to Economic Growth: Some Empirical Evidence'. *World Development*, 16: 1329–39.

Ernst, D., and Ravenhill, J. (1999). 'Globalization, Convergence and the Transformation of IPNs in Electronics in East Asia'. *Business and Politics*, 1: 35–62.

Eskeland, G., and Harrison, A. E. (2003). 'Moving to Greener Pastures? Multinationals and the Pollution Havens Hypothesis'. *Journal of Development Economics*, 70: 1–23.

Esty, D. (1993). *Greening the GATT*. Cambridge, Mass.: MIT Press.

—— and Gentry, B. (1997). 'Foreign Investment, Globalization and the Environment', in T. Jones (ed.), *Globalization and the Environment*. Paris: OECD.

—— and Ivanova, M. (2002). *Global Environmental Governance: Options and Opportunities*. New Haven: Yale School for Forestry and the Environment.

Evans, P. (1995). *Embedded Autonomy: States and Industrial Transformation*. Princeton: Princeton University Press.

—— and Rauch, J. E. (1999). 'Bureaucracy and Growth: A Cross National Analysis of the Effects of "Weberian" State Structures on Economic Growth'. *American Sociological Review*, 64: 748–65.

Fan, C. C., and Scott, A. J. (2003). 'Industrial Agglomeration and Development: A Survey of Spatial Economic Issues in East Asia and a Statistical Analysis of Chinese Regions'. *Economic Geography*, 79: 295–319.

Felker, G. B. (1998). 'Upwardly Global: The State, Business, and the MNCs in Malaysia's and Thailand's Industrial Transformation'. Ph.D. dissertation. Princeton: Woodrow Wilson School.

—— (1999). 'Malaysia's Innovation System: Actors, Interests and Government', in K. S. Jomo and G. Felker (eds.), *Technology, Competitiveness and the State*. New York: Routledge, 98–147.

—— (2001). 'The Politics of Industrial Investment Policy Reform in Malaysia and Thailand', in K. S. Jomo (ed.), *Southeast Asia's Industrialization: Industrial Policy, Capabilities and Sustainability*. London: Palgrave, 129–82.

—— (2003). 'Southeast Asian Industrialization and the Changing Global Production System'. *Third World Quarterly*, 24/2: 255–82.

—— and Jomo, K. S. (1999). 'Introduction', in K. S. Jomo and G. Felker (eds.), *Technology, Competitiveness and the State*. New York: Routledge, 1–37.

Frankel, J., and Romer, D. (1999). 'Does Trade Cause Growth'. *American Economic Review*, 89: 379–99.

Gereffi, G. (1995). 'Global Production Systems and Third World Development', in B. Stallings (ed.), *Global Change, Regional Response: The New International Context of Development*. Cambridge: Cambridge University Press, 100–42.

Gertler, M. S. (1995). 'Being There: Proximity, Organization and Culture in the Development and Adoption of Advanced Manufacturing Technologies'. *Economic Geography*, 71: 1–26.

Gilbert, C. L. (1986). 'Professor Hendry's Econometric Methodology'. *Oxford Bulletin of Economics and Statistics*, 48: 283–307.

—— (1989). 'LSE and the British Approach to Time Series Econometrics'. *Oxford Economic Papers*, 41: 108–28.

Girling, J. S. (1981). *Thailand: Society and Politics*. Ithaca, NY: Cornell University Press.

Global Cement Information (2000). *Market Place Global Cement*. Nyborg, Denmark: GCI.

Goldman, M., Ergas, H., Ralph, E., and Felker, G. (1997). 'Technology Institutions and Policies'. World Bank Technical Paper No. 383. Washington: World Bank.

Grabowski, R. (1994). 'The Successful Developmental State: Where Did It Come From?' *World Development*, 23: 413–22.

Graedel, T. E., and Allenby, B. R. (1995). *Industrial Ecology*. Upper Saddle River, NJ: Prentice Hall.

Greene, W. H. (2000). *Econometric Analysis*, 4th edn. Upper Saddle River, NJ: Prentice Hall.

Greiner, T. (1984). 'The Environmental Manager's Perspective on Toxics Use Reduction Planning'. M.S. thesis. Boston: Massachusetts Institute of Technology.

GROSSMAN, G., and KRUEGER, A. (1993). 'The Environmental Impacts of NAFTA', in P. Garber (ed.), *The US–Mexico Free Trade Agreement*. Cambridge, MA: MIT Press.

GUNNINGHAM, N., and GRABOWSKI, P. (1998). *Smart Regulation: Designing Environmental Policy*. New York: Oxford University Press.

HAGGARD, S. (1990). *Pathways from the Periphery*. Ithaca, NY: Cornell University Press.

HAJER, M. (1995). *The Politics of Environmental Discourse: Ecological Modernization and the Policy Process*. Oxford: Clarendon Press.

HALL, R., and JONES, C. I. (1999). 'Why do Some Countries Produce so Much More Output per Worker than Others?' *Quarterly Journal of Economics*, February, 114: 83–116.

HAMILTON, T. (1995). 'Pollution as News: Media and Stock Market Reaction to the Toxics Release Inventory Data'. *Journal of Environmental Economics and Management*, 28: 98–113.

HARRISON, A. (1996). 'Determinants and Effects of Direct Foreign Investment in Côte d'Ivoire, Morocco, and Venezuela', in M. Roberts and J. Tybout (eds.), *Industrial Evolution in Developing Countries*. New York: Oxford University Press, 163–86.

HAUSKER, K. (1999). 'Re-inventing Environmental Regulation: The Only Path to a Sustainable Future'. *Environmental Law Reporter*, 29: 10148–57.

HAUSMAN, J. (1978). 'Specification Tests in Econometrics'. *Econometrica*, 46: 98–113.

HAZILLA, M., and KOPP, R. (1990). 'Social Cost of Environmental Quality Regulations: A General Equilibrium Analysis', *Journal of Political Economy*, 98: 853–73.

HENDERSON, J., DICKEN, P., HESS, M., COE, N., and YEUNG, H. (2002). 'Global Production Networks and the Analysis of Economic Development'. *Review of International Political Economy*, 9: 436–64.

HENDRIKS, C. A., WORRELL, E., de JAGER, D., BLOK, K., and RIEMER, P. (1998). *Emission Reduction of Greenhouse Gases from the Cement Industry*. Interlaken, Switzerland: International Energy Agency.

HENDRY, D. (1985). 'Econometric Methodology'. Paper presented to the Econometric Society Fifth World Congress. Boston: MIT.

—— and RICHARDS, J. F. (1982). 'On the Formation of Empirical Models in Dynamic Econometrics'. *Econometrics*, 20: 3–33.

—— —— (1983). 'The Econometric Analysis of Time Series'. *International Statistical Review*, 51: 111–63.

HERSH, R. (1996). 'A Review of Integrated Pollution Control in Selected Countries'. Discussion Paper 97–117. Washington: Resources for the Future.

HETTIGE, H., HUQ, M., PARGAL, S., and WHEELER, D. (1996). 'Determinants of Pollution Abatement in Developing Countries: Evidence from South and South East Asia'. *World Development*, 24: 1891–904.

—— MANI, M., and WHEELER, D. (1997). *Industrial Pollution in Economic Development: Kuznets Revisited*. Washington: World Bank, Development Research Group.

HILL, H. (1996). *The Indonesian Economy since 1966*. Cambridge: Cambridge University Press.

HOBDAY, M. (1997). *Innovation in East Asia: The Challenge to Japan*. Cheltenham: Edward Elgar.

HOBDAY, M. (2001). 'The Electronics Industries of the Asia-Pacific: Exploiting IPNs for Economic Benefit'. *Asia-Pacific Economic Literature*, 15: 13–29.

—— (2002). *Technology Needs Assessment for Developing Countries*. Vienna: United Nations Industrial Development Organization.

Holcim Ltd. (2002). *Providing Foundations for Society's Future: Corporate Sustainable Development Report 2002*, downloaded at http://www.holcim/Upload/CORP/Publications/CSDR_final_18Oct02.pdf on November 25, 2003.

HOWARD, J., NASH, J., and EHRENFELD, J. (2000). 'Standard or Smokescreen? Implementation of a Voluntary Environmental Code'. *California Management Review*, 42: 63–82.

HSIAO, M. (1999). 'Environmental Movements in Taiwan', in Y. F. Lee and A. Y. So (eds), *Asia's Environmental Movements: Comparative Perspectives*. Armonk: M. E. Sharpe, 31–54.

HSIN-HUANG, M. H. (1998). *Taiwan's Environmental Movements*. Mimeo, Department of Sociology, Academia Sinica, Taipei, Taiwan.

HUFF, W. G. (1999). 'Singapore's Economic Development: Four Lessons and Some Doubts'. *Oxford Development Studies*, 21: 33–55.

HUMPHREY, J., and SCHMITZ, H. (2002). 'How does Insertion in Global Value Chains affect Upgrading in Industrial Clusters?' *Regional Studies*, 36: 1017–27.

ISO (2003). *The ISO Survey of ISO 9000 and ISO 14001 Certificates*. Geneva: ISO.

JOHANSSON, H., and NILSSON, L. (1997). 'Export Processing Zones as Catalysts'. *World Development*, 25: 2115–28.

JOHNSON, C. (1982). *MITI and the Japanese Miracle*. Stanford, Calif.: Stanford University Press.

JOHNSTON, B. F., and KILBY, P. (1975). *Agriculture and Structural Transformation*. New York: Oxford University Press.

—— and MELLOR, J. (1961). 'The Role of Agriculture in Economic Development'. *American Economic Review*, 51: 566–91.

JOMO, K. S. (2001). 'Introduction: Growth and Structural Change in the Second-Tier Southeast Asian NICs', in K. S. Jomo (ed.), *Southeast Asia's Industrialization: Industrial Policy, Capabilites and Sustainability*. New York: Palgrave, 1–29.

—— and ROCK, M. (2003). 'Resource Exports and Resource Processing for Export in Southeast Asia', in E. Aryeetey, J. Court, M. Nissanke, and B. Weder (eds.), *Asia and Africa in the World Economy*. Tokyo: United Nations University Press, 128–75.

—— and TODD, P. (1994). *Trade Unions and the State in Peninsular Malaysia*. Kuala Lumpur: Oxford University Press.

JONES, L., and SAKONG, I. (1980). *Government, Business and Entrepreneurship: The Korean Case*. Cambridge, Mass: Harvard University Press.

JUSTMAN, M., and TEUBAL, M. (1995). 'Technology Infrastructure Policy (TIP): Creating Capabilities and Building Markets'. *Research Policy*, 24: 259–81.

KANG, D. (2002). *Crony Capitalism: Corruption and Development in South Korea and the Philippines*. Cambridge: Cambridge University Press.

KAY, C. (2002). 'Why East Asia Overtook Latin America: Agrarian Reform, Industrialization and Development'. *Third World Quarterly*, 23: 1073–102.

KEESING, D. (1988). 'The Four Exceptions'. UNDP-World Bank Trade Expansion Programme. Occasional Paper No. 2. New York: United Nations.

KHATOR, R. (1991). *Environment, Development, and Politics in India*. Lanham, Md.: University Press of America.

KIM, L. (1993). 'National System of Industrial Innovation: Dynamics of Capability Building in Korea', in Richard R. Nelson (ed.), *National Innovation Systems: A Comparative Analysis*. New York: Oxford University Press, 357–83.

—— (1997). *From Imitation to Innovation*. Boston: Harvard Business School Press.

—— and NELSON, R. R. (2001). *Technology, Innovation, and Learning*. Cambridge: Cambridge University Press.

KING, A. A., and LENOX, M. J. (2000). 'Industry Self-Regulation without Sanctions: The Chemical Industry's Responsible Care Program'. *Academy of Management Journal*, 43: 696–716.

KNACK, S., and KEEFER, P. (1995). 'Institutions and Economic Performance: Cross-Country Tests using Alternative Institutional Measures'. *Economics and Politics*, 3: 207–27.

KONAR, S., and COHEN, M. A. (1997). 'Information as Regulation: The Effect of Community Right to Know Laws on Toxics Emissions'. *Journal of Environmental Economics and Management*, 32: 109–24.

KORTEN, D. (1995). *When Corporations Rule the World*. San Francisco: Berrett-Koehler Publishers.

LAFFONT, J., and TIROLE, J. (1991). 'The Politics of Government Decision Making: A Theory of Regulatory Capture'. *Quarterly Journal of Economics*, 106: 1089–127.

LALL, S. (1992). 'Technological Capabilities and Industrialization'. *World Development*, 22: 645–54.

LEE, D. H., BAE, Z.-T., and LEE, J. (1991). 'Performance and Adaptive Roles of the Government Supported Research Institute in South Korea'. *World Development*, 19: 1421–40.

LEE, K. Y. (2000). *From Third World to First: The Singapore Story: 1965–2000*. New York: Harper Collins.

LEE, Y. F., and SO, A. Y. (eds.) (1999). *Asia's Environmental Movements: Comparative Perspectives*. Armonk, NY: M. E. Sharpe.

LEONARD, H. J. (1988). *Pollution and the Struggle for the World Product*. New York: Cambridge University Press.

LEUNG, C. K. (1993). 'Personal Contacts, Subcontracting Linkages, and Development in the Hong Kong–Zhujiang Delta region'. *Annals of the Association of American Geographers*, 83: 272–302.

LIM, P. L. (2004). *Policy Integration Environmental Supply Chain: A Malaysian Case Study*. Vienna: UNIDO.

LIU, S.-J. (1998). 'Industrial Development and Structural Adaptation in Taiwan: Some Issues of Learned Entrepreneurship'. *IEEE Transactions on Engineering Management*, 45: 338–48.

LOHANI, B. (1998). *Environmental Challenges in Asia in the 21st Century*. Manila: Asian Development Bank.

LOW, P. (ed.) (1992). *International Trade and the Environment*. Washington: The World Bank.

—— and YEATS, A. (1992). 'Do Dirty Industries Migrate?', in P. Low (ed.), *International Trade and the Environment*. Washington: World Bank, 89–104.

Lucas, R., Wheeler, D., and Hettige, H. (1992). 'Economic Development, Environmental Regulation and the International Migration of Toxic Industrial Pollution: 1960–1988', in P. Low (ed.), *International Trade and the Environment*. Washington: World Bank, 67–86.

Mabry, B. (1979). *The Development of Labor Institutions in Thailand*. Data Paper No. 112. Ithaca, NY: SEA Program, Department of Asian Studies, Cornell University.

MacIntyre, A. (1994). 'Power, Prosperity, and Patrimonialism: Business and Government in Indonesia', in A. MacIntyre (ed.), *Business and Government in Industrializing Asia*. Ithaca, NY: Cornell University Press, 244–67.

—— (2000). 'Funny Money: Fiscal Policy, Rent-Seeking and Economic Performance in Indonesia', in M. H. Khan and K. S. Jomo (eds.), *Rents, Rent-Seeking and Economic Development: Theory and Evidence from Asia*. Cambridge: Cambridge University Press, 248–73.

McKean, C., Toh, K., and Fisher, W. (1994). 'Export and Investment Promotion in Thailand', USAID Technical Report No. 17. Washington: Center for Development Information and Evaluation.

McKendrick, D. (1992). 'Obstacles to "Catch Up": The Case of the Indonesian Aircraft Industry'. *Bulletin of Indonesian Economic Studies*, 28: 39–66.

Mani, S. (2000). 'Policy Instruments for Stimulating R&D in the Enterprise Sector: The Contrasting Experiences of Two MNC Dominated Economies from Southeast Asia'. UNU INTECH Discussion Paper 2000–9. Maastricht, The Netherlands: UNU: INTECH.

Mardon, R. (1990). 'The State and the Effective Control of Foreign Capital'. *World Politics*, 43: 111–38.

Markusen, J. R. (1995). 'The Boundaries of Multinational Enterprises and the Theory of International Trade'. *Journal of Economic Perspectives*, 9: 169–89.

Maskell, P. (2001). 'Regional Policies: Promoting Competitiveness in the Wake of Globalisation', in D. Felsenstein and M. Taylor, *Promoting Local Growth: Process, Practice and Policy*. Aldershot: Ashgate, 295–310.

Mellor, J. W., and Johnston, B. F. (1984). 'The World Food Equation: Interrelations among Development, Employment, and Food Consumption'. *Journal of Economic Literature*, 22: 531–74.

Ministry of the Environment (1994). *Environmental Protection in Korea: 1994*. Seoul: Ministry of the Environment.

Mol, A., and Sonnenfeld, D. (2000). *Ecological Modernization and the World: Perspectives and Critical Debates*. London: Frank Cass.

Motorola, Inc. (2002). *Motorola: 2002 Global Corporate Citizenship Report*. Schaumburg, Ill.: Motorola, Inc.

Moutchnik, A. (2003). 'Theoretical Perspectives on the Diffusion of Environmental Management Standards'. Fourth Oikos Ph.D. Summer Academy, University of Gallen, Switzerland.

Murphy, K., Shleifer, A., and Vishny, R. (1991). 'Why is Rent-Seeking So Costly to Growth?' *American Economic Review*, 83: 409–14.

Muscat, R. J. (1994). *The Fifth Tiger: A Study of Thai Development Policy*. Armonk, NY: M. E. Sharpe.

National Academy of Public Administration (NAPA) (1995). *Setting Priorities, Getting Results: A New Direction for the EPA*. Washington: NAPA.

NELSON, R. R. (1993). *National Innovation Systems: A Comparative Analysis*. Oxford: Oxford University Press.

NEUMAYER, E. (2000). 'Trade and the Environment: A Critical Assessment and Some Suggestions for Reconciliation'. *Journal of Environment and Development*, 9: 138–59.

O'CONNOR, D. (1994). *Managing the Environment with Rapid Industrialization: Lessons from the East Asian Experience*. Paris: OECD.

OOI, G. L. (1994). 'Centralized Approach in Environmental Management: The Case of Singapore'. *Sustainable Development*, 2: 17–22.

PANAYOTOU, T. (1999). 'The Effectiveness and Efficiency of Environmental Policy in China', in M. B. McElroy, C. P. Nielson, and P. Lydon (eds.), *Emerging China: Reconciling Environmental Protection and Economic Growth*. Cambridge, Mass.: Harvard University Press, 431–72.

PARGAL, S., MANI, M., and HUQ, M. (1997). 'Inspections and Emissions in India: Puzzling Survey Evidence of Industrial Water Pollution'. Washington: World Bank.

—— and WHEELER, D. (1996). 'Informal Regulation of Industrial Pollution in Developing Countries: Evidence from Indonesia'. *Journal of Political Economy*, 104: 1314–27.

PECK, J., and TICKELL, A. (2002). 'Neo-liberalizing Space'. *Antipode*, 34: 380–404.

PONGPAICHIT, P. (1980). 'The Open Economy and its Friends: The Development of Thailand'. *Pacific Affairs*, 53: 439–57.

POON, J. P. H., and THOMPSON, E. R. (1998). 'Foreign Direct Investment and Economic Growth: Evidence from Asia and Latin America'. *Journal of Economic Development*, 232: 141–60.

RANIS, G. (1993). 'Labor Markets, Human Capital and Development Performance in East Asia'. Background paper for *The East Asian Miracle*. Washington: World Bank.

RASIAH, R. (1995). *Foreign Capital and Industrialization in Malaysia*. Basingstoke: Macmillan.

—— (2001). 'Politics, Institutions, and Flexibility: Microelectronics, Transnationals and Machine Tool Linkages in Malaysia', in F. C. Deyo, R. F. Doner, and E. Hershberg (eds.), *Economic Governance and the Challenge of Flexibility in East Asia*. New York: Rowman and Littlefield, 165–90.

REPELLIN-HILL, V. (1999). 'Trade and the Environment: An Empirical Analysis of the Technology Effect in the Steel Industry'. *Journal of Environmental Economics and Management*, 38: 283–301.

RHEE, Y. H., ROSS-LARSON, B., and PURSELL, G. (1984). *Korea's Competitive Edge: Managing Entry into World Markets*. Baltimore: Johns Hopkins University Press.

RIDEOUT, D. W., and ALLEN, N. V. (1999). *A Tiger in the Making—The National Science and Technology Development Agency (NSTDA): The Potential, the Realities, and the Opportunities*. Canada: National Resource Council of Canada, Confidential Report on Golden Jubilee Project 906/18864.

ROBERTS, M., and TYBOUT, J. (eds.) (1996). *Industrial Evolution in Developing Countries*. New York: Oxford University Press.

ROCK, M. T. (1984). 'Rural (Provincial) Industry and Thai Development: A Policy Framework'. Bangkok: USAID/Thailand.

—— (1992). 'Public Sector Marketing and Production Assistance to South Korea's Manufacturing Exporters: Did It Make a Difference?' *Development Policy Review*, 10: 339–57.

—— (1994). 'Transitional Democracies and the Shift to Export-Led Industrialization: Lessons from Thailand'. *Studies in Comparative International Development*, 29: 18–37.

—— (1995). 'Thai Industrial Policy: How Irrelevant was it to Export Success?' *Journal of International Development*, 7/5: 745–57.

—— (1996*a*). 'Pollution Intensity of GDP and Trade Policy: Can the World Bank be Wrong?' *World Development*, 24: 471–9.

—— (1996*b*). 'Toward More Sustainable Development: The Environment and Industrial Policy in Taiwan'. *Development Policy Review*, 14: 255–72.

—— (1999). 'Re-assessing the Role of Industrial Policy in Indonesia: Can the Neoliberals be Wrong?' *World Development*, 27: 413–27.

—— (2000). 'Thailand's Old Bureaucratic Polity and its New Semi-Democracy', in M. H. Khan, and K. S. Jomo (eds.), *Rents, Rent-Seeking and Economic Development: Theory and Evidence from Asia*. Cambridge: Cambridge University Press, 182–206.

—— (2002*a*). *Pollution Control in East Asia: Lessons from the Newly Industrializing Economies*. Washington: Resources for the Future and Singapore: Institute for Southeast Asian Studies.

—— (2002*b*). 'Integrating Environmental and Economic Policy-Making in China and Taiwan'. Paper prepared for MacArthur Foundation Workshop on Globalization, Governance and the Environment, Institute for International Studies, University of California, Berkeley, California, April 14–15, 2000. *American Behavioral Scientist*, May, 45/9: 1435–55.

—— (2002*c*). 'Exploring the Impact of Selective Interventions in Agriculture on the Growth of Manufactures in Indonesia, Malaysia, and Thailand'. *Journal of International Development*, 14: 485–510.

—— (2003). 'The Politics of Development Policy-Making in New Order Indonesia'. Paper presented at graduate seminar on Economic Policy Reform in Asia at the Department of Political Science and the William Davidson Institute, University of Michigan, Ann Arbor. William Davidson Institute, Working Paper No. 632.

—— Angel, D., and Feridhanusetyawan, T. (2000). 'Industrial Ecology and Clean Development'. *Asia Journal of Industrial Ecology*, 3: 29–42.

—— and Bonnett, H. (2004). 'The Comparative Politics of Corruption: Accounting for the East Asian Paradox in Empirical Studies of Corruption, Growth and Investment'. *World Development*, 32: 999–1017.

Rodrik, D. (2002). 'Keynote Speech at Alternatives to Neo-liberalism Conference'. Carnegie Endowment for International Peace, Washington, May 23.

—— Subramanian, A., and Trebbi, F. (2002). 'Institutions Rule: The Primacy of Institutions over Geography and Integration in Economic Development'. Working Paper No. 9305. October. Cambridge, Mass.: National Bureau of Economic Research.

Roht-Arriaza, N. (1995). 'Shifting the Point of Regulation: The International Organization for Standardization and Global Lawmaking on Trade and the Environment'. *Ecology Law Quarterly*, 22: 479–539.

Rosen, C. M., Beckman, S., and Bercovitz, L. (2003). 'The Role of Voluntary Industry Standards in Environmental Supply-Chain Management', *Journal of Industrial Ecology*, 6: 103–23.

—— Bercovitz, L., and Beckman, S. (2000). 'Environmental Supply-Chain Management in the Computer Industry: A Transactions Cost Economics Perspective'. *Journal of Industrial Ecology*, 4/4: 83–104.

Russell, M. (1990). 'Monitoring and Enforcement', in P. R. Portney (ed.), *Public Policies for Environmental Protection*. Washington: Resources for the Future, 243–74.

Sachs, J., and Warner, A. (1995). 'Economic Reform and the Process of Global Integration'. *Brookings Papers on Economic Activity*, 1: 1–118.

Sarkis, J. (2003). Special Issue of *Greener Management International*, 35.

Schmitz, H., and Nadvi, K. (1999). 'Clustering and Industrialization: Introduction'. *World Development*, 27: 1503–14.

Scott, A. J. (1994). 'Variations on the Theme of Agglomeration and Growth: The Gem and Jewellery Industry in Los Angeles and Bangkok'. *Geoforum*, 253: 249–63.

—— (1998). *The Coming Shape of Global Production, Competition, and Political Order*. Oxford: Oxford University Press.

—— (2002). 'Regional Push: Towards a Geography of Development and Growth in Low- and Middle-Income Countries'. *Third World Quarterly*, 23: 137–61.

Searle, P. (1999). *The Riddle of Malay Capitalism*. St Leonards, NSW, Australia: Allen and Unwin.

Siam City Cement Public Company Ltd. (2002*a*). *Environmental Initiatives*. Bangkok, Thailand: Siam City Cement Public Company Limited.

—— (2002*b*). *Annual Report, 2002*. Bangkok, Thailand: Siam City Cement Public Company Limited.

—— (n.d.*a*). *Technical Learning Organization Guide Book*. Tabkwang, Keangkoi, Saraburi, Thailand: Siam City Cement Public Limited Company.

—— (n.d.*b*). *SCCC-SP Separator*. Bangkok, Thailand: Siam City Cement Public Limited Company.

Simon, H. (1961). *Administrative Behavior*, 2nd edn. New York: Macmillan.

Smil, V. (1997). *China's Environmental Crisis: An Inquiry into the Limits of National Development*. Armonk, NY: M. E. Sharpe.

Spofford, W., Ma, Xianying, Zou, J., and Smith, K. (1996). 'Assessment of the Regulatory Framework for Industrial Pollution Control in Chongqing'. Mimeo. Washington: Resources for the Future.

Stevens, C. (1993). 'Harmonization, Trade and the Environment'. *International Environmental Affairs*, 5: 42–9.

Stigler, J. (1971). 'The Theory of Economic Regulation'. *Bell Journal of Economics*, 2: 3–21.

Storper, M. (1997). *The Regional World*. New York: Guilford Press.

—— Thomadikis, S., and Tsipouri, L. J. (1998). *Latecomers in the Global Economy*. London: Routledge.

Suehiro, A. (1992). 'Capitalist Development in Postwar Thailand: Commercial Bankers, Industrial Elite, and Agribusiness Groups', in R. McVey (ed.), *Southeast Asian Capitalists*. Ithaca NY: Cornell University Press, 48–9.

TALUKDAR, D., and MEISNER, C. M. (2001). 'Does the Private Sector Help or Hurt the Environment: Evidence from Carbon Dioxide Pollution in Developing Countries'. *World Development*, 29/5: 827–40.

TAYLOR, C. R., and WIGGENS, S. N. (1997). 'Competition or Compensation: Supplier Incentives under the American and Japanese Subcontracting Systems'. *American Economic Review*, 87: 598–618.

TEUBAL, M. (1996). 'R&D and Technology Policy in NICs as a Learning Process'. *World Development*, 24: 449–60.

—— (2002). 'What is the Systems Perspective to Innovation and Technology Policy (TIP) and How can we Apply it to Developing and Newly Industrialized Economies?' Mimeo. Jerusalem, Israel: Hebrew University.

The Economist (1999). 'Bagged Cement', June 19, 351/8124: 66.

THOMPSON, E. (2002). 'Clustering of Foreign Direct Investment and Enhanced Technology Transfer: Evidence from Hong Kong Garment Firms in China'. *World Development*, 30: 873–89.

Times Academic Press (1993). *Challenge and Response: Thirty Years of the Economic Development Board*. Singapore: Times Academic Press.

TIMMER, C. P. (1993). 'Rural Bias in the East and Southeast Asian Rice Economy'. *Journal of Development Studies*, 30: 149–76.

TOBEY, J. (1990). 'The Effects of Domestic Environmental Policies on Patterns of World Trade: An Empirical Test'. *Kyklos*, 43: 191–209.

TYBOUT, J. R. (1996). 'Heterogeniety and Productivity Growth: Assessing the Evidence', in M. J. Roberts, and J. R. Tybout (eds.), *Industrial Evolution in Developing Countries*. New York: Oxford University Press, 43–72.

UNCTAD (2001). *World Investment Report: Promoting Linkages*. New York: United Nations Conference on Trade and Development.

UNDP (2003). *Making Global Trade Work for People*. London: Earthscan.

UNEP (1999). *Asia Pacific Environmental Outlook*. Paris: UNEP.

UNESCAP (2001). *State of the Environment in Asia and the Pacific*. Bangkok: United Nations.

UNIDO (1999). *UNIDO Industrial Statistics Database: 1999*. Geneva, Switzerland: Statistics and Information Networks Branch, United Nations Industrial Development Organization.

—— (2002*a*). *Industrial Development Report, 2002/2003: Competing through Innovation and Learning*. Vienna: United Nations Industrial Development Organization.

—— (2002*b*). *Assessing the Uptake of Environmentally Sound Technology*. Vienna: United Nations Industrial Development Organization.

United States Department of Energy (2004). *Energy Outlook 2004*. Washington: Government Printing Office.

US EPA (1994). 'Alternative Control Techniques Document: NO_x Emissions from Cement Manufacturing'. EPA-453/R-94-004. Washington: Office of Air and Radiation, US EPA.

VAN OSS, H. G., and PADOVANI, A. C. (2002). 'Cement Manufacture and the Environment, Part I: Chemistry and Technology'. *Journal of Industrial Ecology*, 6: 89–105.

—— —— (2003). 'Cement Manufacture and the Environment, Part II: Environmental Challenges and Opportunities'. *Journal of Industrial Ecology*, 7: 93–126.

VINCENT, J., ALI, R. M., and RAHIM, K. A. S. (2000). 'Water Pollution Abatement in Malaysia', in D. P. Angel and M. T. Rock (eds.) (2000), *Asia's Clean Revolution: Industry, Growth and the Environment*. Sheffield: Greenleaf Publishing, 173–93.

WADE, R. H. (1990). *Governing the Market*. Princeton: Princeton University Press.

—— (2003). 'What Development Strategies are Viable for Developing Countries Today? The WTO and the Shrinking of "Development (and Democratic) Space" ' . Mimeo. London: London School of Economics.

WANG, H., and WHEELER, D. (1996). 'Pricing Industrial Pollution in China: An Econometric Analysis of the Levy System'. World Bank Policy Research Department Working Paper No. 1644. Washington: World Bank.

WESTPHAL, L. (1978). 'The Republic of Korea's Experience with Export-Led Industrial Development'. *World Development*, 6: 347–82.

—— (1981). 'Korea's Industrial Competence: Where Did it Come From'. World Bank Staff Working Paper No. 469. Washington: World Bank.

—— (2001). 'Technology Strategies for Economic Development in a Fast-Changing Global Economy'. Mimeo. Swarthmore College.

WHEELER, D., and MARTIN, P. (1992). 'Prices, Policies and the International Diffusion of Clean Technology: The Case of Wood Pulp Production', in P. Low (ed.), *International Trade and the Environment*. Washington: World Bank, 197–224.

WILLIAMSON, O. E. (1981). 'The Modern Corporation: Origins, Evolution and Attributes'. *Journal of Economic Literature*, 19: 1537–68.

—— (1996). 'Economics of Organization: A Primer'. *California Management Review*, 38: 131–46.

World Bank (1990). *World Development Report, 1990*. New York: Oxford University Press.

—— (1992). *World Development Report, 1992*. New York: Oxford University Press.

—— (1993). *The East Asian Miracle*. New York: Oxford University Press.

—— (1994*a*). *Thailand: Mitigating Pollution and Congestion in a High Growth Economy*. Washington:World Bank.

—— (1994*b*). *Indonesia: Environment and Development*. Washington: World Bank.

—— (1997). *Can the Environment Wait? Priorities for East Asia*. Washington: World Bank.

—— (1998*a*). *World Development Indicators*. Washington: World Bank.

—— (1998*b*). *East Asia: The Road to Recovery*. Washington: World Bank.

—— (1999). *Malaysia: Enterprise Training, Technology and Productivity*. Washington: World Bank.

—— (2000). *Greening Industry*. Washington: World Bank.

—— (2004). *World Development Indicators: 2004 on CD-ROM*. Washington: World Bank.

World Resources Institute (1997). *World Resources*. Washington: WRI.

XING, Y., and KOLSTAD, C. (1998). 'Do Lax Environmental Regulations Attract Foreign Investment?' Working Paper No. 28–98. University of California, Santa Barbara.

YEUNG, H. (1998). *Transnational Corporations and Business Networks*. London: Routledge.

Young, O. (1997). *Global Governance*. Cambridge, Mass.: MIT Press.

Zarsky, L. (1999). 'Havens, Halos, and Spaghetti: Untangling the Evidence about Foreign Direct Investment and the Environment', in OECD, *Foreign Direct Investment and the Environment*. Paris: OECD.

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